MACHINE DESIGN

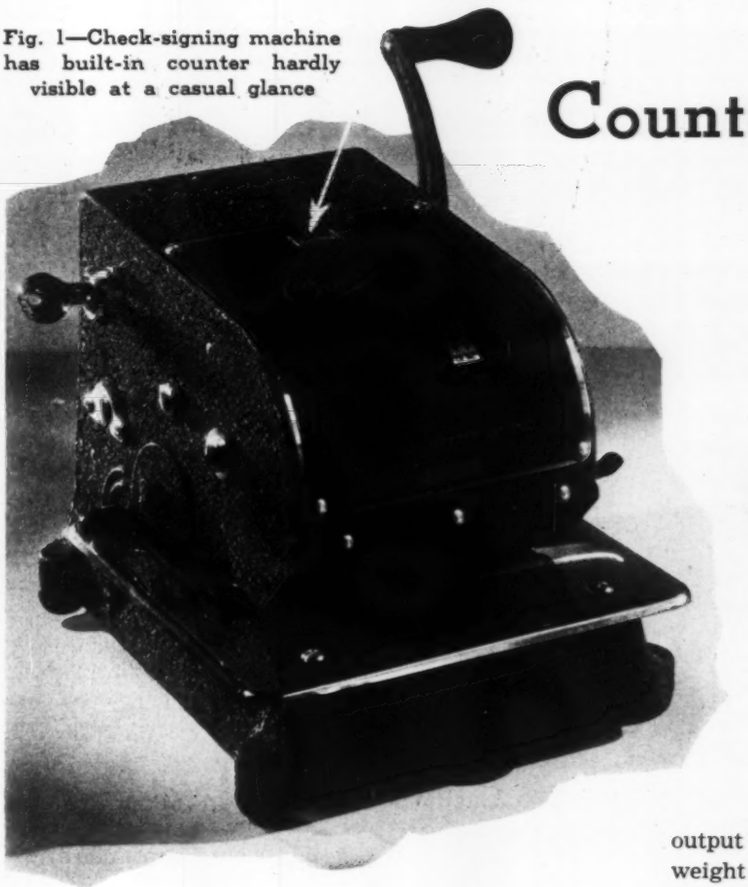


Fig. 1—Check-signing machine has built-in counter hardly visible at a casual glance

# Counting Instruments Add to Machine Value

By Fred J. Kelly

ADVANTAGES of keeping an accurate check on the output of a machine are known by every engineer. Yet the same executive who will ask for an accounting of every cent spent in his department will often allow production machines under his supervision to run with only a casual check on their efficiency. Management, too, insists that employes make an accurate record of their working time, but often neglects to extend this supervision to machines turning out thousands of parts a day.

Usually, however, fault is in the inadequate method of checking machine output rather than a lack of any check at all. In many cases, small parts are weighed by the thousands to determine the rate of output without consideration for variations in the weight of metal, lost pieces, ends of stock that have been discarded, etc. When machined pieces are counted by hand it is a slow and tedious process, human error always exists and there is the chance that intentional mistakes will be made in favor of the operator. The answer to this inefficient method of checking machine output is the installation and building into machines of counting mechanisms which will give an unprejudiced and absolutely accurate count.

Application of counting instruments to industrial machinery goes back about 60 years, but it is only recently that machine designers have begun to install these devices as original equipment. It has been the practice until the last few years for the users of such machines as printing presses, punch presses, textile machines and general wood and metalworking machines, where a count on production is de-

sired, to buy and install their own counters. Only with the widespread use of vending machines, automatic phonographs, coin-operated gambling devices, etc., where a very accurate check on the coin input is needed have counters begun to be built in as original equipment. However, with the trend in all types of machinery for manufacturers to provide built-in motors, electrical controls and lighting equipment, etc., it is natural they should realize the advantages of supplying counters that are an integral part of the machine.

Unquestionably, as the benefits of accurate counting of parts is realized the demand for machines with built-in counting instruments will increase. Not only can a counter be more advantageously placed if provision is made in the design of the machine, but a more foolproof mechanism for picking up the count is possible. Moreover, appearance of a well-styled machine will often be destroyed by attaching an accessory of any kind in a prominent position—counters are no exception. *Figs.* 1 and 2 are good examples of design in which the counters are definitely a part of the machine and do not stand out like parts tacked on as an afterthought. Design of the check signer (*Fig.* 1) made by Hall-Welter Co. is such as to make it impossible to disconnect or tamper with the counter; therefore a dependable record of the number of signatures is assured. Every time the drill head is raised or lowered in the drill press (*Fig.* 2) of the Dalrae Tools Co., a count is made by the instrument shown built into the machine.

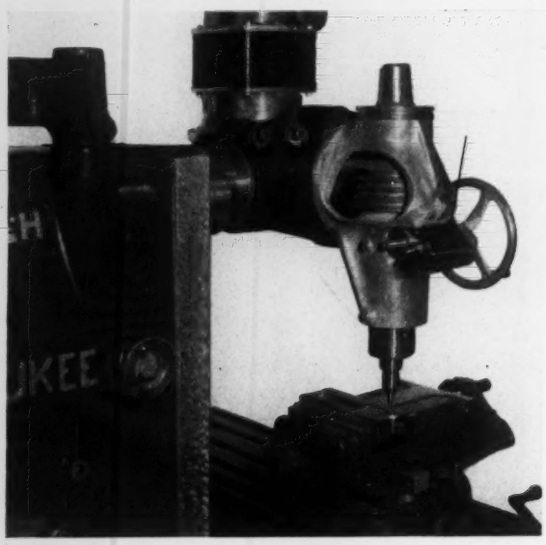
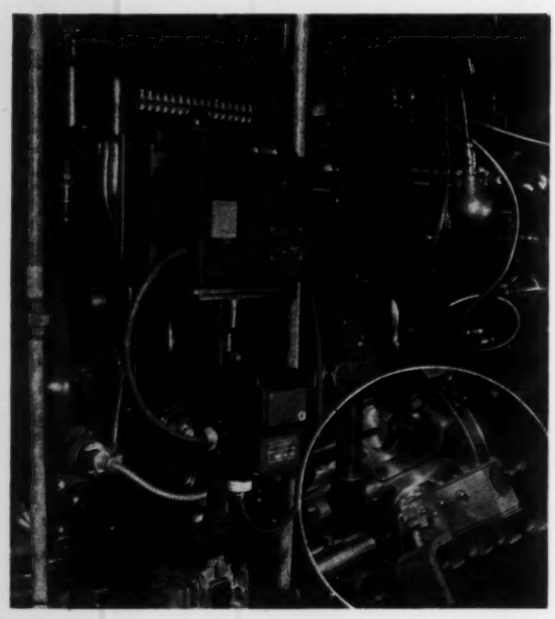
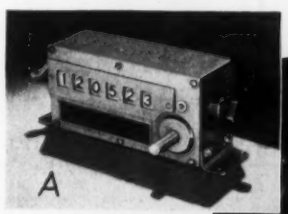


**Fig. 2—Movement of drill head up and down actuates counter built on front of machine**

**Fig. 3—Unit mounted on machine gives written record of count, time and reasons for delays**



Counters may be broadly classified in two types according to their mode of operation, namely: Reciprocating or stroke counting, and rotary or revolution counting. There are hundreds of variations of these basic types to accomplish the innumerable applications for counting in industry. Among the factors to be determined in applying counters to machines are the number of dials, maximum speed of operation, method of counter actuation, and whether continuous (nonresetting) or counters that can be reset to any number by wing nut or key and lock are required. Included in the many types that are available are worm drive instruments, waterproof models, counters fitted with wheels for measuring rope or other continuously moving material and the various electrical counting devices.



## Electrical Counters Are Popular

Lately there has been a pronounced popularity of electrical counting instruments. By the use of these the recording instrument can be some distance removed from the point at which the count is made or the count recorder may be placed away from the machine altogether. In certain instances where it is desirable that the operator not be aware a count is being made on his machine, the recording instrument is in another room from the machine and only the switch to pick up the count is placed on the machine in such a manner that it is not visible. Electrical counters may be actuated by the interception of the beam from a photoelectric cell. They are well adapted for counting pieces too light for mechanical counting as the contactors make and break by a feather touch. Tight corners in which there is room for a small contactor but not for an entire counting mechanism are installations to which only the electrical counter can be adapted. Some trouble

has been experienced in perfecting contactor switches that will make and break at high speed for millions of counts but which cannot be jarred by machine vibration to give an untrue count. These conditions have been successfully met, however, and a number of switches are now available which perform satisfactorily. Most switches are sealed against dirt and oil and do not require attention of any kind. Shown at *B* in *Fig.* 4 is a common type of rotary counter, electrically actuated.

Stroke and rotary counters are available in single and double-deck models or with two sets of figures arranged side by side. The double deck counters (See *C* in *Fig.* 4) have one set of dials which run continuously giving a record of total production, and another set operating simultaneously to provide a count of the current run and is reset for subsequent runs. Predetermining counters in single or double deck models permit a certain count to be preset on them before the run is started. By means of an electrical connection, a bell is rung, a light flashed or the machine automatically stopped when the preset count is reached. Just developed is a ratio differential control for counters which multiplies the speed of a mechanical counter, depending on the desired ratio of counting to counter speed. Frequent reason for inaccuracies is the limited counting speed of the instruments, but with the ratio differential control this is considerably increased and as great a count as 5000 per minute has been made with a standard reset counter.

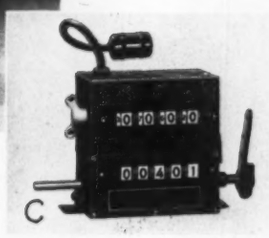



**Fig. 4—Shown at A is a worm-driven counter with shaft projecting from front and rear. B is an electrically-actuated counter and C is a double-deck model, having one set of dials running continuously and another which can be set to record current run**

Combining a counting mechanism with a mechanical or synchronous clock to give the time in which the count is performed is a recent innovation which increases the utility of the counter. In this type of instrument a written record is printed on a chart that is read as easily as a typewritten report. Whenever a count is begun or ended, the time is printed on the record and one can see at a glance just when the machine was in operation and the number of parts that were turned out. Further developments have been made in this instrument, and one model is provided now with a dialing device whereby the machine operator may account for any time the machine is not in operation. Letters on the dial stand for reasons that the machine might be idle, such as: repairs, tool set-up, down for stock, tool grinding, etc. The letter corresponding to the reason for the machine's idleness is printed on the record with the time the machine is not running. Thus a complete check on the machine's operation is possible. All delays are accounted for and the written record of the count shows exactly when trouble was experienced by the operator. In *Fig.* 3 a unit of the type described is shown mounted on an Acme-Gridley automatic, multiple spindle screw machine. In the inset is the switch contactor for picking up the count as pieces are fed into a machine. Wires from the contactor to the counter are encased in a copper tube, preventing any chance of short circuit or broken wires.

In building counters into machines, rotary counters are commonly used as their shafts may be di-

(*Continued on Page* 88)

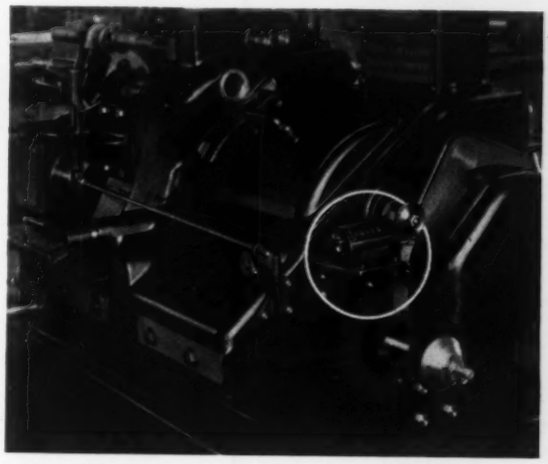
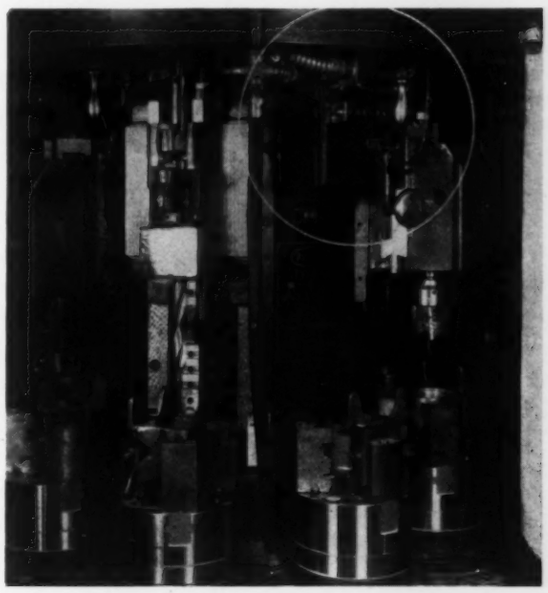


**Fig. 5—Counter on chucking machine is conveniently placed for operator to keep check on work run**

**Fig. 6—To prevent tampering with counter on multiple-spindle automatic, actuating mechanism is completely enclosed inside machine**



# Scanning THE FIELD FOR Ideas

WITH ability to handle a heavy mixture of sand and gravel in water as readily as it delivers clear water, the unique pump shown in *Fig.* 1 is capable of handling practically any liquid which will flow through a pipe. This Moino pump, which is a product of Robbins & Myers, Inc., was invented in France by R. Moineau and met with early success in the French aeronautical service.

The actual pumping elements, which are shown in enlarged detail in the upper part of the illustration, consist of a stationary shell called the stator, and an inner revolving member called the rotor assembly. The stator, whose bore is in the form of a double threaded helix, is made of Thiokol synthetic rubber in order effectively to resist the action of oil, solvents, acids, etc., as well as the abrasive action of sand or other grit carried by the liquids which are pumped.

The rotor is in the form of a single threaded helix of such shape and pitch that it meshes with and turns in a helix of the stator. As it turns, it effects a positive endwise displacement of the liquid in the remaining space of the open helix, maintaining sealed contact throughout its length thus eliminating valves. Since it is positive in displacement, has almost no working clearances, and has no suction or discharge valves to lift, the pump is self-priming within 1½ inch mercury gage of barometer.

The action of the rotor can be likened to that of a piston in a cylinder of infinite length, the flow being both uniform and positive. While theoretically there is no limit to the discharge head that can be handled, the slight running clearance and deformation actually do allow a very small amount of slippage to occur. Therefore in the simple form illustrated, the efficient maximum delivery head is in the region of 150 to 200 feet of water. By combining two or more stators and rotors in the line of flow, 500 to 800 feet of discharge head can be obtained.

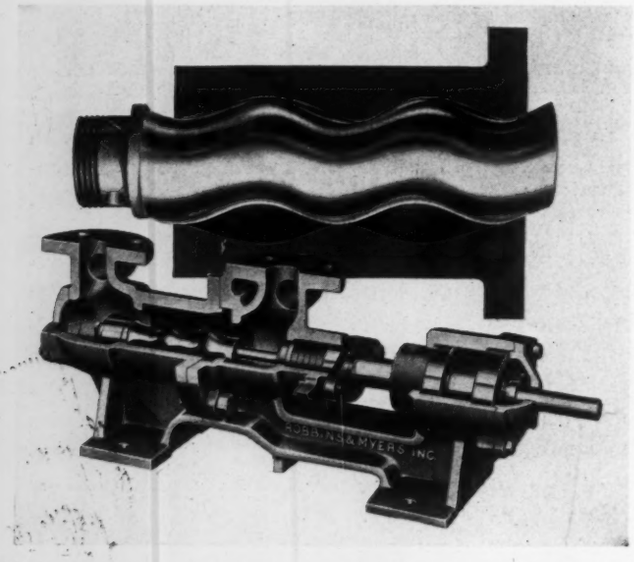



**Fig. 1—Action of helical rotor of this pump is like that of a piston in a cylinder of infinite length**

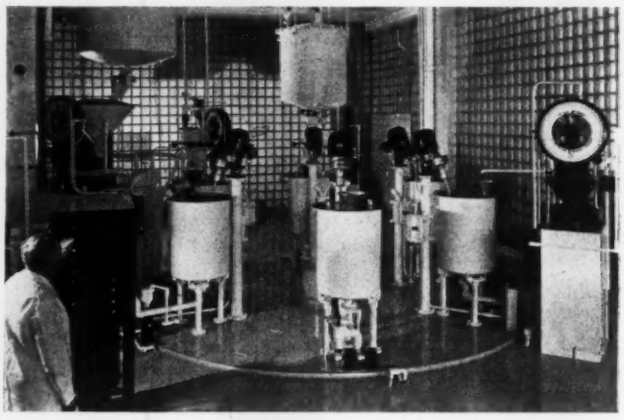


**Fig. 2—Automatic batch mixing is effected by coordination of turntable with pre-weighing feed units**

The maximum size of solids which the pump will pass safely is equal approximately to one-half the clearance space between open helix and rotor. Up to one-fourth volume of sand to water is readily pumped.

## Turntable Expedites Mixing

PURITY, uniformity and attractive packaging of pharmaceutical and toilet preparations are essentials to continued success in their merchandizing. It is an interesting sidelight that under modern technique of design the clean and highly efficient plants

from which these products emanate are in many cases as attractive as are the products and the packages in which they are sold.

Increasing recognition by equipment designers of

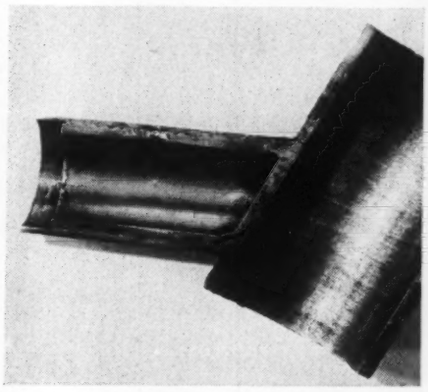


**Fig. 3—Section through bicycle weld, showing reenforcement in tube**

the possibilities of enameled metal, stainless steel, glass, plastics, etc., is playing a large part in bringing about the combination of good appearance with operating efficiency in modern plants where such processing is carried out. A striking example of this is given by *Fig.* 2 which shows a corner in the new plant of the Campana Co.

Five glass-lined tanks, each equipped with its own motor-driven agitator, are mounted on an indexing turntable flush with the floor. At each indexed position of this turntable a tank receives injections of certain ingredients. This is accomplished through the action of several Toledo scale units with which the tanks "register" as they pause between steps in indexing. These scale units, which are equipped with photoelectric cut-offs, accurately preweigh their respective materials before discharging them.

## Joints Are Free From Flash

OF INTEREST to designers because it opens up new possibilities for the use of tubing in machine construction, the Hart process of resistance welding now makes possible unusually strong joints free from external flash. This is a patented process, rights to which are owned by Steel & Tubes Inc., subsidiary of the Republic Steel Corp. The cross-sectioned Hart process weld, *Fig.* 3 above, is off the newly installed bicycle frame production line of the Cleveland Welding Co.

When light gage tubing is involved, the end is first punch-expanded slightly to a depth of 1½ to 2 inches. Into this socket is placed a short piece of heavily cross-knurled tubing. Then by passage through a die the outside tube is drawn down to its original diameter, thus firmly embedding the knurled piece. In production this reinforcing is carried out automatically in a hopper feed machine developed by the Taylor-Winfield Corp.

Next the reinforced tube is machined so as to have line contact with its mating member at its inner edge only—this being done in a double-end Taylor-Winfield semi-automatic milling machine at the rate of 700 tube ends per hour. Finally the joint is effected in a press welder equipped with air-operated clamping and pressure mechanism. Work like that shown is done under 1 to 2 tons pressure, 150 to 250 kilovolt amperes and 4 to 10 cycles of a 6-cycle current being employed. Current is turned on by an electronic control and the cycle reversed—the entire cycle occupying only 2 or 3 seconds.

*Fig.* 3, which is a macrograph of a bicycle head joint, demonstrates the complete fusion of outer tube, reinforcement and mating tube, and complete lack of external upset or flash. There is minimum change in grain structure because of the rapidity of welding.

## Gaging Effectiveness of Design

DESIGNERS in the automobile industry carry on their work with the knowledge that regardless of how carefully and completely they may figure strength of vital parts, no theoretical or practical test will be spared these parts once they have been made. The tests range all the way from highly scientific ones in the laboratory to rough and ready ones on the proving ground, but all of them are based on sound common sense and are aimed to insure operating safety and dependability.

That the work in the laboratory is decidedly practical as well as theoretical is made clear by *Fig.* 4, which shows Leo Olick and Jack Kelly investigating a passenger car rear axle assembly in the laboratory of

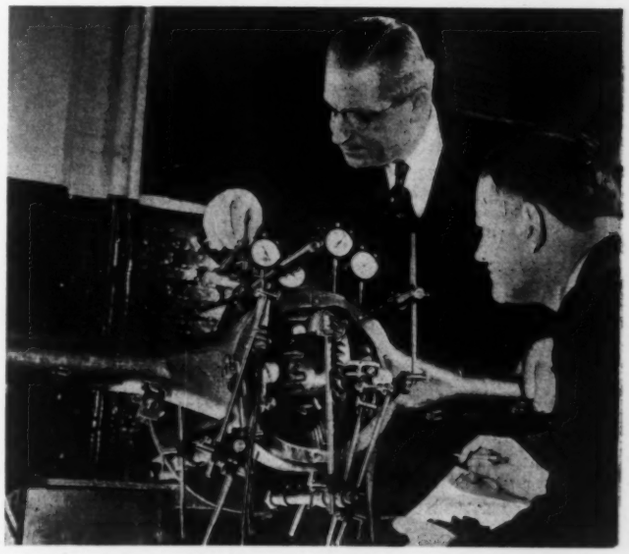


**Fig. 4—Laboratory test by means of indicators shows actual deflections in rear axle assembly under load**

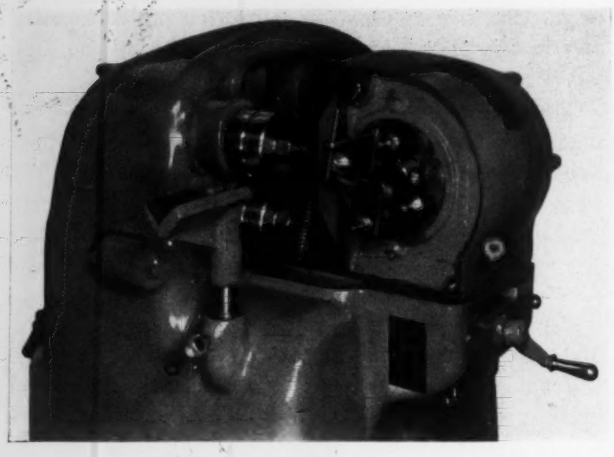


**Fig. 5—Shaftless motor enables wooden rods to be fed through in connection with rounding operation**

the Chevrolet gear and axle plant in Detroit. They have mounted twelve indicators so that they are in contact with vital points of housing, shafts, gears, etc. A weight hung on the end of the drive shaft simulates maximum load on the axle in service.

## Machine Rounds Square Rods

AN INGENIOUS application of a shaftless motor is depicted by *Fig.* 5. This is a machine for producing round rods, dowels, etc.—either straight or spiral and from ¼ to 2-inches in diameter—from square sticks of wood. It is a development of the J. A. Fay & Egan Co.

The sticks, which are fed and guided by power driven rollers at both front and back of the motor, pass directly through the center of the motor, which is of totally enclosed, fan-cooled type, of 5 horsepower, running at 3600 revolutions per minute. The stick does not turn but a hollow-center cutter head connected to the armature of the motor whirls around the stick, thereby machining it rapidly and smoothly from square to round form as it feeds through. Rods up to 1⅛ inches are fed from the right side of the machine, whereas larger ones are fed from the left side.

The blocks carrying the cutters are guided in straight grooves in their disk, allowing the cutting edges to move radially from the center of the head when adjusting them for cutting size. The motor head unit is mounted on a cross slide to permit its being moved forward to give access to the head.

## Power Chucking Relieves Operator

FURTHER easing of the physical burden ordinarily imposed upon the operator of a turret lathe is the primary purpose of a design refinement just introduced by The Warner & Swasey Co. This development, which is shown on the machine in *Fig.* 6, is a power-driven chuck wrench. It is an interesting example of the continuing trend toward substitution of electrical power for muscle power in the field of metalworking.

This device, which in effect becomes an integral part of the machine when attached by its standard adapters, can be set to function in connection with chucks ranging in diameter from 12 to 28 inches. While designed primarily for use with three-jaw universal scroll chucks, it can also be used with four-jaw independent chucks, or—for that matter—with any chucks having radial wrench sockets.

As is clear from the illustration, the unit is powered by a flange-mounted torque motor operating through a worm gear reduction. Wide variation in gripping pressures is made possible by the use of a drum-type transformer giving a selection of eight different voltages. This transformer, together with the magnetic contactors which control starting, stopping and reversing of the motor, are housed in the box on the top of the headstock. The voltage selector is on the end of this box, the tip of its handle being just visible in the cut. This selective voltage makes it possible to suit gripping pressure to work, whether it be thin tubing, or a massive forging or casting.

To use the device the operator first stops the chuck and lines up a mark on its diameter with a pointer indicator on the machine. Next he engages the square nose of the chuck wrench with the chuck screw. This is done by pulling the spade handle which can be seen at the upper left in the cut. Operating through linkage and levers, this slides the wrench shaft in its driving pinion. Turning this same spade handle to left or right then turns on the power to open or close the chuck as desired.

A complete interlock is provided between this power wrench unit and the machine clutch lever, thus making it impossible to engage the machine starting clutch without first safely withdrawing the nose of the wrench from the socket in the chuck.

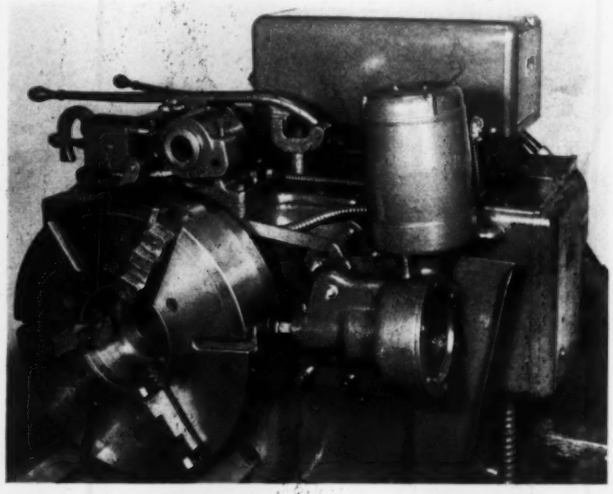


**Fig. 6—Driven by torque motor with voltage selector, power chuck wrench suits gripping action to work**

# General Considerations in Designing Mechanical Springs

## *Part III—Compression and Tension Springs*

By A. M. Wahl*

Fig. 2—Fracture of helical spring starts from nucleus at inside of coil and progresses to the wire axis

STRESSES EMPLOYED IN PRACTICE FOR HELICAL COMPRESSION SPRINGS—The method of design described in Part II (February, MACHINE DESIGN) enables the determination of allowable working stress in helical compression springs of different indices, provided the endurance properties and yield point in torsion of the spring wire are known. This method is based on a rational interpretation of available fatigue test data for combined static and variable loading, with stress concentration effects present. Though such a method is preferable to one based largely on the designer's judgment, there are cases where the required data are not known for the material or wire size used. To aid the designer in such cases, a tabulation of working stress values for helical springs used as a basis for design by the company with which the writer is associated is given in Table I[1].

It will be noted that lower stresses are used for the larger wire sizes and for severe service in accordance with practical experience. The classification of particular applications as severe, average, or light service depends to a considerable extent on the judgment of the designer. In general, however, springs subjected to continuous fatigue stressing in pulsating load application, where the ratio of minimum to maximum stress is one-half or less (as in valve springs, for example) would be considered as under severe service. On the other hand, a spring subjected to but a few applications of load during its life or subjected to prac-

*Mechanics division, research laboratories, Westinghouse Electric & Mfg. Co.

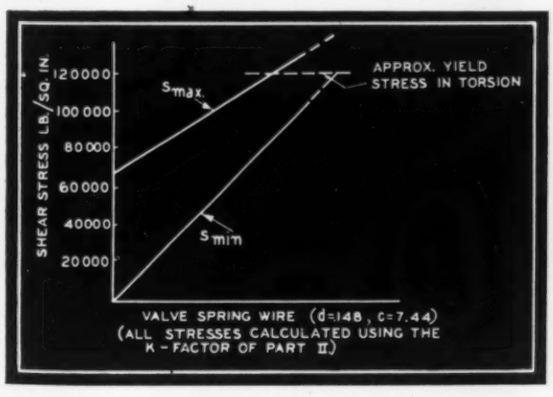



Fig. 1—Typical endurance diagram for carbon steel springs shows point at which yield takes place

1. Working stress values in this table are given merely as a guide and are not necessarily recommended values.

TABLE I

**Working Stresses in Shear-Helical Compression Springs (Steel)***

| Diameter of Wire, inches | Severe Service | Average Service | Light Service |
|---|---|---|---|
| Up to .085 | 60,000 | 75,000 | 93,000 |
| Above .085 to .185 | 55,000 | 69,000 | 85,000 |
| Above .185 to .320 | 48,000 | 60,000 | 74,000 |
| Above .320 to .530 | 42,000 | 52,000 | 65,000 |
| Above .530 to .970 | 36,000 | 45,000 | 56,000 |
| Above .970 to 1.5 | 32,000 | 40,000 | 50,000 |

*For springs made of a good quality spring steel. All stresses based on the use of the K-factor of Part II. The table does not hold where corrosion effects are present. For phosphor bronze springs 50% of these values are used.

tically a constant load at normal temperature would probably be considered as under light service. Examples of such service are the springs in certain circuit breaker operating mechanisms, safety valve springs, etc.

It will be found, in general, the stresses given in Table I are conservative, particularly for springs having the smaller indices and under constant loads. (In such cases the factor $C_w$ of Part II will approach 2.) Where a careful analysis of spring requirements is made by the methods of Part II, and using fatigue test data available (See Table II, page 33), an increase in these stresses will in many cases be found justifiable, particularly if careful control of the spring material and manufacturing process is maintained by the spring maker. On the other hand, where failure of the spring is very serious, lower stresses than those given in the table may be advisable. Where possible, a rational analysis, based on the methods of Part II and using a definite factor of safety, is preferable to the somewhat empirical choice of working stress involved by the use of Table I.

TYPICAL ENDURANCE TEST RESULTS—HELICAL COMPRESSION SPRINGS—A typical endurance diagram for helical springs under combined static and variable loading is given in *Fig.* 1. This particular curve is based on actual fatigue tests by Zimmerli[2] on pretempered carbon steel valve springs of .148 inch diameter and index $c=7.44$. It may be seen that as the stress range $s_{max}$—$s_{min}$ is decreased, the maximum permissible stress is increased considerably. However, it should be noted that, as mentioned in Part I, for stresses approaching the yield point some permanent set will occur, and this is often objectionable in practice.

A typical fatigue fracture of a helical spring is shown in the photograph of *Fig.* 2. It will be noted that the failure starts from a nucleus at the inside of the coil (at *a*, *Fig.* 3) and progresses along a plane at an angle of about 45 degrees to the wire axis. The reason the fractures usually start at the point *a* is clear from *Fig.* 3, which indicates the approximate distribution of the shearing stress along a transverse diameter of the wire cross section in a spring of small index. From this figure it may be seen that the stress on the inside of the coil is much greater than that on the outside.

**Fig. 3—Shearing stress distribution is depicted over cross section of helical spring of small index, assuming elastic conditions**

## Fatigue of Different Materials Varies

A summary of the results of certain tests on springs of different wire diameters and different indices, carried out by various investigators, is given in Table II. Values of the endurance limit $s_e''$ (stress range from zero to maximum)[3] and of the maximum stress $s_{max}$ for intermediate ranges (from $s_{min}$ to $s_{max}$) are given. For comparison the approximate yield point $s_y$ as determined by torsion tests is also given. Some of these test results were obtained on springs made from wires which had been carefully inspected to insure freedom from scratches, seams or other imperfections. Hence, the results may not be entirely representative in cases where such close control of the wire properties is not maintained; for such cases lower endurance values may be expected and a higher factor of safety must be used. For springs subjected to a considerable stress range in fatigue, surface imperfections are usually objectionable, particularly if they occur inside the coil near the point of maximum stress. The reason for this is that a fatigue crack may start at points where such imperfections are located, and then spread until complete failure of the spring occurs.

In general, the values shown in Table II indicate that considerable variation in the results obtained by fatigue tests for different materials and wire sizes may be expected.

SPRINGS SUBJECTED TO FEW STRESS CYCLES—Very little test data are at hand for springs subjected to few stress cycles—say under 10,000. The fatigue tests on acid *OH* carbon steel springs made by Johnson[4] indicate that such springs (with an index of 4.8) will stand about 10,000 cycles at 130,000 pounds per square inch (0 to maximum) before failure, while at 65,000 pounds per square inch they may be subjected to 10 million cycles without failure. Similar results were obtained on heat treated chrome-vanadium steel springs. However, no tests were made where the spring is subjected to occasional cycles of high stress while under continuous fatigue loading at a lower stress, a condition which often occurs in practice. In such cases, it is probable that the life of the spring would be lower than expected. To illustrate, if the stress application had been as follows: One cycle at

2. University of Michigan, *Engineering Research Bulletin* No. 26.

3. It should be noted that $s_e''$ refers to the endurance limit for pulsating stress determined by tests on the actual spring with index $c$, while $s_e'$ (used in *Figs.* 9 to 11 of Part II) refers to that determined by tests on a spring of large index ($c=\infty$).

4. *Iron Age*, March 15, 1934.

130,000 pounds per square inch (0 to maximum) then 100 cycles at say 60,000 pounds per square inch, then one cycle at 130,000 pounds per square inch and so on, it is doubtful whether the spring would stand anything approaching 10,000 cycles at 130,000 pounds per square inch. The reason for this is that microscopic fatigue cracks may be opened as a consequence of the higher stress, and these cracks could easily be propagated by repeated cycles at the lower stress.

HELICAL COMPRESSION SPRINGS UNDER CONSTANT LOAD—When springs are under practically a constant load, in line with the discussion of Part I, the stress concentration effect due to wire curvature (represented by the factor $K_c$ of Part II) may be neglected in figuring the stress. Thus, if the stress $s_{max}$ has been calculated by using the $K$-factor of *Fig.* 4, Part

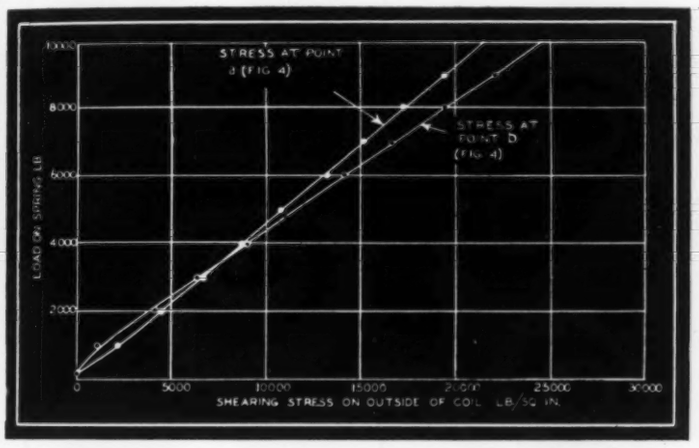



**Fig. 5—Results of stress test on helical spring showing effect of eccentricity of loading**

II (or if the charts of *Figs.* 5 and 6, of Part II, have been used) then this stress should be divided by $K_c$ to get a stress which may be used for comparative design purposes. The stress $s_{wo}$ thus obtained may be considered the working stress under static loading. Thus[5]

$$s_{wo} = \frac{s_{max}}{K_c} = \frac{s_y}{N} \quad \ldots\ldots (1)$$

where $s_{max}$ is the working stress figured by using the $K$-factor, $s_y$ is the torsional yield point, and $N$ is the

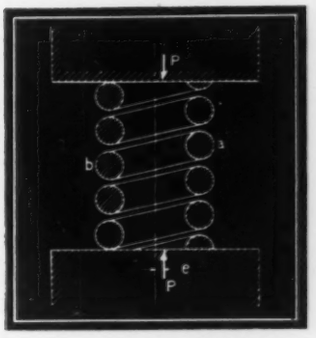



**Fig. 4—Loading helical spring in compression results in eccentricity as shown**

factor of safety. It should be noted that this method applies only where the load is practically constant, or has but a slight ripple superimposed on the constant load.

SPRINGS OPERATING AT ELEVATED TEMPERATURES—The previous discussion is based on the assumption that the springs are operating at normal temperatures. When operation occurs at elevated temperature, the endurance limit, yield point, and modulus of elasticity in torsion, in general, are reduced. In addition, during long periods of time at operating stresses, considerable creep or permanent set may take place, this creep being a function both of stress and time. The effect of corrosion also may become of importance. Very little test data have been published on the behavior of helical springs at elevated temperatures[6].

EFFECT OF VARIATIONS IN COIL AND WIRE DIAMETERS—The effect of small variations in coil diameter and wire diameter may be estimated quantitatively as follows: The known deflection formula for helical springs (see Part II) is:

$$\delta = \frac{64\,Pr^3n}{Gd^4} \quad \ldots\ldots (2)$$

In this formula let us suppose that $r$ and $d$ are the *nominal* mean coil radius and wire diameter respectively. Suppose now that the *true* mean coil radius and wire diameter are $r_o = r\,(1+\epsilon)$ and $d_o = d\,(1+\lambda)$

5. The same result may be obtained by using equation (14) of Part II and taking $s_{min}/s_{max}=1$ (const. load). This gives $s_{max}=s_yK_c/N$ and from equation (11) of Part II, $s_{wo}=s_{max}/K_c$.

6. Data on allowable stresses at elevated temperatures are given by Whiting, MACHINE DESIGN, February, 1936.

TABLE II

**Endurance Test Results on Helical Compression Springs (1)**

| Material | Bar or Wire Diameter inches | Index c | Estimated End. Lim. $s_e$ 0-max. lb./in.² | $s_{max}$. Range ¼ to max. lb./in.² | $s_{max}$. Range ½ to max. lb./in.² | $s_y$ (Approx.) (2) lb./in.² | Investigator |
|---|---|---|---|---|---|---|---|
| Cr-Va steel heat treated | 0.148 | 7.44 | 75,000 | 87,000 | 100,000 | 120,000 | Zimmerli (3) |
| Pretempered carbon steel | 0.148 | 7.44 | 70,000 | 80,000 | 100.000 | 120,000 | Zimmerli (3) |
| Pretempered carbon steel | 0.148 | 7.44 | 58,000 | 70,000 | 88,000 | 100,000 | Zimmerli (3) |
| Acid OH, carbon steel | 0.562 | 4.8 | 70,000 | ..... | ..... | 118,000 | Johnson (4) |
| Chrome vanadium steel | 0.562 | 4.8 | 77,000 | ..... | ..... | 141,000 | Johnson (4) |
| Electric carbon steel | ¾ | 5 | 58,200 | ..... | ..... | 95,000 | Edgerton (5) |
| Open hearth carbon steel | ¾ | 5 | 72,700 | ..... | ..... | 119,000 | Edgerton (5) |
| Cold wound carbon steel 0.6% C. | 0.225 | 8 | 44,000 | ..... | ..... | ..... | Hengstenberg (6) |
| Electric carbon steel 0.9%C | 0.225 | 8 | 69,000 | ..... | ..... | ..... | Hengstenberg (6) |

(1) All stresses figured by using the K-factor of Part II.
(2) Yield point estimated. This may be determined from a torsion curve as the point where the plastic unit shearing strain is 0.2%
(3) Univ. of Mich. Eng. Sp. Rep. No. 26.
(4) *Iron Age*, March 15, 1934.
(5) *Transactions*, A. S. M. E., October, 1937.
(6) Tests by Hengstenberg, Westinghouse Research Laboratories.

where $\epsilon$ and $\lambda$ are small quantities. The true deflection then becomes:

$$\delta_1 = \frac{64\,Pr_o^3 n}{Gd_o^4} = \frac{64\,Pr^3(1+\epsilon)^3 n}{Gd_o^4(1+\lambda)^4} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Since we have assumed $\epsilon$ and $\lambda$ to be small relative to unity, this equation may be written with sufficient accuracy:

$$\delta_1 = \frac{64\,Pr^3 n}{Gd^4}(1+3\epsilon-4\lambda) \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

It is seen that the true deflection $\delta_1$ is merely the nominal deflection $64\,Pr^3n/Gd^4$ multiplied by a term $1+3\epsilon-4\lambda$ which depends on $\epsilon$ and $\lambda$. Suppose now that the actual mean coil diameter or radius was 1 per cent greater than the nominal, i.e., $\epsilon=.01$, while at the same time the true wire diameter is 1 per cent *less* than the nominal or $\lambda=-.01$. Putting these values of $\epsilon$ and $\lambda$ in (4) we get:

$$\delta_1 = 1.07\,\frac{64\,Pr^3 n}{Gd^4}$$

In other words under such conditions with a 1 per cent *cumulative* variation in coil and wire diameter from the nominal values the actual deflection will be 1.07 times the nominal deflection or 7 per cent greater.

As a practical example let us take an actual case examined by the author. This spring was made of nominal 9/16 inch wire or $d=0.5625$ inch. After cutting up the spring and measuring the dimensions, it was found that the average wire diameter was 0.551 inch which would correspond to an error in the wire size of $(.5625-.551)/.5625=2.04$ per cent, i.e., $\lambda=-.02$. Assuming that the true mean coil diameter of this spring were equal to the nominal, i.e. that $\epsilon=0$, then from equation (4) the true deflection $\delta_1$ would be $1-4\lambda=1.08$ times the calculated value. The actual coil diameter, however, had been made about 2 per cent less than the nominal, which meant that $\epsilon$ was $-.02$. Using this value in equation (4) the true deflection becomes 1.02 times the nominal deflection. Thus, the actual coil diameter had been made slightly smaller than the nominal value in order to compensate for the decreased diameter of the wire used. Since commercial wire stock may easily vary by 2 per cent or more from the nominal value, it is clear that if the spring rate is to be held within close limits some leeway must be given the spring manufacturer to vary the coil diameter or number of turns accordingly.

In a similar manner it may be shown that a 1 per cent variation in the wire diameter means approximately a 3 per cent variation in the stress; a 1 per cent change in the coil diameter, a 1 per cent change in stress. Usually, however, the stress does not have to be held to such close limits as the deflection; however, a consideration of the effect of commercial variations in wire size on the stress may be advisable for certain highly stressed spring applications.

TORSIONAL MODULUS OF ELASTICITY VARIES FOR DIFFERENT SPRING MATERIALS—In calculating the deflection of helical springs from equation (2) it is essential, for accurate results, that a correct value of torsional modulus of elasticity $G$ be used. The actual value of this quantity, however, depends on the spring material, and to some extent on the wire size[7]. A value of $G$ which would be expected for carbon steel on the basis that the modulus of elasticity in tension $E=30\times10^6$ pounds per square inch and Poisson's ratio is 0.3 would be $G=11.5\times10^6$ pounds per square inch. This can be determined from the known relation between these quantities based on elastic theory. Tests made under the writer's direction on three carbon steel springs of large index and ½ inch diameter wire, heat treated after coiling, showed an average value of $G=11.47\times10^6$ pounds per square inch. Similar tests on springs from another manufacturer shows an average value of $G=11.23\times10^6$ pounds per square inch. These tests were made by measuring deflections in the body of the coil to eliminate the disturbing effect of the end turns. After the tests the

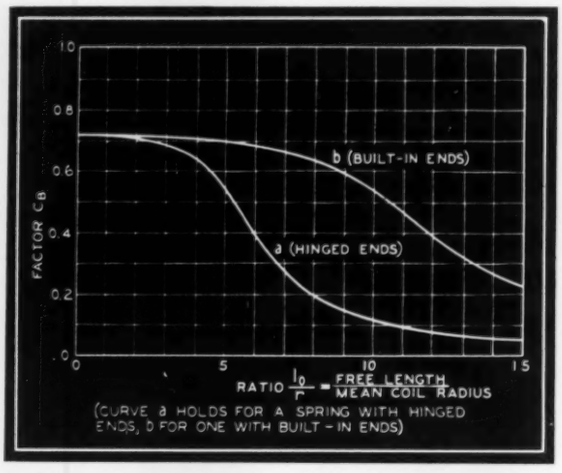



**Fig. 6—Curves on graph enable designer to find buckling load factor**

average coil and wire diameters were accurately determined by cutting up the springs and making micrometer measurements. These values are not far from the value of $11.5\times10^6$ pounds per square inch estimated from the elastic properties of the material. Springs stressed to higher stresses, such that some permanent set occurs, will show lower values of $G$. In general, as the temperature increases the value of $G$ drops[7]. A table of approximate values of $G$, for some commonly used spring material at normal temperatures is given below.

TABLE III

**Approximate Values of Torsional Modulus of Elasticity G**

| | |
|---|---|
| Carbon and Chrome-Vanadium Steels | $11.5\times10^6$ lb./in.² |
| Stainless 18-8, Hard Drawn | $10.5\times10^6$ lb./in.² |
| Monel Metal | $9\times10^6$ lb./in.² |
| Phosphor Bronze | $6\times10^6$ lb./in.² |

EFFECT OF ECCENTRICITY OF LOADING IN COMPRESSION SPRINGS—When a helical spring is loaded in com-

7. Data on the torsional modulus for different spring materials at both normal and elevated temperatures are given in the article by Whiting mentioned in footnote 6.

pression, the resultant load in general will not lie along the spring axis, but will be displaced by some amount $e$, as indicated in *Fig.* 4. This results in an increase in stress over the calculated value. The actual amount of this eccentricity depends mainly on the shape of the end turns and also on the parallelism of the loading surfaces. Results of stress measurements using sensitive extensometers on a large helical spring (1½ inch wire diameter, 6 inches outside diameter) in compression are indicated in *Fig.* 5. One line represents the stress measured on the outside of the coil at $a$ (*Fig.* 4); the other represents that on a diametrically opposite point $b$. It may be seen that the stress on one side is around 13 per cent greater than that on the opposite side, due to eccentricity of loading. Unfortunately this eccentricity varies with different springs, and cannot at present be calculated with any degree of accuracy.

### Eccentricity Varies Widely

Some years ago the writer had occasion to make a series of tests on small helical springs in compression to determine eccentricity of loading. This was in connection with an application where it was desired to maintain as nearly as possible a central load on a compression spring. The tests were carried out using a three-point loading arrangement with dead weights. Values of eccentricity thus measured varied from 4 to 30 per cent of the coil radius, considerable scatter being evident in the results. It has been found that eccentricity could be reduced by increasing the number of active coils (with the inactive turns remaining the same), thus indicating that this effect is primarily due to the end coils.

The effect of eccentricity of loading in increasing the stress may be estimated as follows: Let $\epsilon$ be the eccentricity as a fraction of the mean coil radius. Then the actual stress is found (approximately) by multiplying the calculated stress by a factor $1+\epsilon$. For example, if the stress calculated by equation (3) of Part II (which assumes central loads) is 60,000 pounds per square inch and if the eccentricity is 0.1 $r$, that is, $\epsilon=0.1$ where $r$ is the coil radius, then the actual stress will be $(1+\epsilon)$ $60{,}000=1.1\times60{,}000=66{,}000$ pounds per square inch. This method should be considered as approximate only.

BUCKLING OF HELICAL COMPRESSION SPRINGS — A problem arising frequently in practical design is that of determining how much load a compression spring may carry without buckling. A solution of this problem involves the study of a column of large flexibility under compression. On this basis, by using known column theory[8] and considering the effects due to shear and direct compression, the critical buckling load $P_{cr}$ may be expressed in the form:

$$P_{cr}=C_B l_o\left(\frac{P}{\delta}\right) \quad \ldots\ldots(5)$$

where $P/\delta$= spring constant of spring=load per inch deflection. (Note: From equation (2) of Part I, $P/\delta=Gd^4/64r^3n$. Also from the chart of *Fig.* 7, Part II, $P/\delta=C_3/n$ where $n$=number of active turns.)

$l_o$=free length of spring.

$C_B$=buckling load factor depending on the ratio $l_o/r$ where $r$= mean coil radius.

Values of $C_B$ are given by the curves of *Fig.* 6. The lower curve marked $a$ shows values when the ends of the spring may be considered as hinged. Such would be the case if the ends were fastened to ball and socket joints. For cases where the ends may be considered as built-in (the ends being held so that no rotation occurs during motion of the spring) the upper curve marked $b$ of *Fig.* 6 may be used. In certain practical cases where the ends of the spring are only partially restrained from rotation, it is safest to use curve $a$ which assumes hinged ends.

It has been found that the values of buckling load given by equation (5) are in agreement with test results on springs having a fairly large number of coils, provided that the coils do not touch before buckling occurs. Because of variations in spring dimensions and the effect of the end turns, however, some inaccuracy in the use of equation (5) is to be expected.

EXAMPLE CALCULATION OF BUCKLING LOAD—As an example of the use of the buckling load factor $C_B$, consider a steel helical compression spring of the following dimensions: Free length $l_o$ = 6 inches, mean coil radius $r$ = 0.75 inches, outside diameter = 1.75 inches, wire diameter 0.25 inches, active turns $n$ = 12. From the chart of *Fig.* 7, Part II, for these dimensions[9] we find $C_3=1700$ and $P/\delta=C_3/n=1700/12=142$ pounds/inch. From *Fig.* 6, the buckling factor $C_B$ is found equal to 0.64 for $l_o/r=6/0.75=8$. (It will be assumed that the ends of the spring are completely restrained from rotation so that curve $b$ of *Fig.* 6 may be used). This is approximately true where the spring is compressed between parallel surfaces. Then from equation (5) the calculated buckling load is $P_{cr}=C_B l_o(P/\delta)=0.64\times6.0\times142=545$ pounds. Assuming a maximum working stress of 60,000 pounds per square inch, the actual load on the spring would be (from the chart of *Fig.* 5, Part II) $P=C_1 s/10{,}000=32\times6=190$ pounds. Under these conditions there is a considerable margin between the working load and the buckling load. If, however, the ends of the spring were hinged, so that no restraint due to rotation occurs, then using curve $a$ of *Fig.* 6, $C_B=0.2$. In this case $P=C_B l_o(P/\delta)=0.2\times6.0\times142=170$ pounds. Hence, with this type of end fastening there would be danger of such a spring buckling before the working load of 190 pounds were reached.

In the concluding article (Part IV) the design of square and rectangular wire springs, tension springs, and torsion springs, will be discussed.

8. See article by Biezeno and Koch, *Zeitschrift Angew. Mathematik und Mechanik*, 1925, p. 279. The derivation is also given in *Theory of Elastic Stability* by Timoshenko, p. 165 (McGraw-Hill, 1936).

9. For greater accuracy, $P/\delta$ should be calculated from equation (2) of Part II.

# Careful Analysis Necessary in Noise Reduction

By Ernest J. Abbott

*TO ELIMINATE noise in machines it is not sufficient merely to mount them resiliently and enclose them in a supposedly soundproof enclosure. Doing this in some instances increases noise. Dr. Abbott, president of the Physicists Research Company, Ann Arbor, Mich., describes a more scientific approach in this article, an abstract of a paper, "New Technique in Noise Reduction", presented recently at a meeting of the Society of Automotive Engineers*

SUCCESSFUL noise reduction consists in reducing vibrational velocities of sound sources by at least a factor of 2 to 3, so that the resulting sound pressure will be reduced ½ to 1/3 of its original value. The methods used are all straight-forward engineering applications of physical principles. Most engineers are familiar with the elements involved, but encounter difficulties because of lack of data on the quantitative relations. Acoustical problems are usually so complex that it is almost impossible to compute results with precision, and accordingly, little attempt has been made to interpret results on the basis of fundamentals. Hence, it has been difficult to accumulate usable backgrounds of experience and thumb-rules. Seven fundamental methods of quieting machines are given, however, in this article.

1. REDUCTION OF MOBILITY—FORCE PRODUCT—In ordinary language the vibrational mobility of an object is simply the ease with which it can be shaken. The mobility of a body is determined by its weight and stiffness, and under some conditions by its frictional resistance to motion. Large friction may reduce mobility. Assuming constant vibrational force, the vibrational velocity is proportional to mobility, and therefore inversely proportional to the weight. Often the sources of vibration are of the "constant displacement" type. A cam and follower is an example of this type of motion. The amount of movement is practically independent of the load moved by the cam,

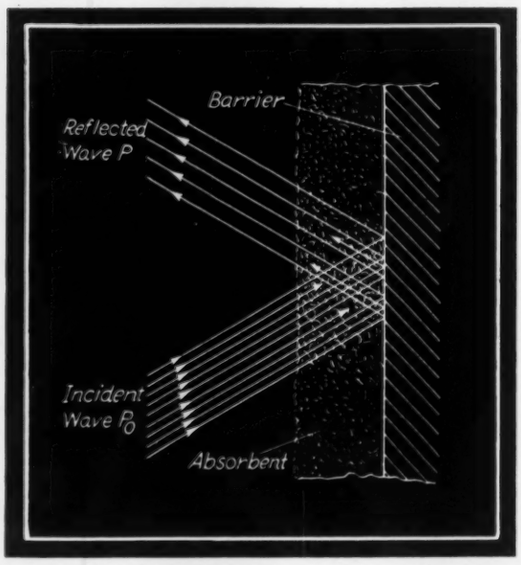



**Fig. 1—Although heavy layer of sound absorbing material is placed on wall, large percentage of noise is reflected**

as any decrease in the mobility of the load is accompanied by a decrease in force required on the cam. Hence, for all speeds of operation, the displacement of the part is the same.

Errors in gears, antifriction bearings, and many other machine parts produce vibrations which are essentially of the constant displacement type. There are minute peculiarities in geometry that pull and push the associated parts positively through small but definite distances exactly like small cam movements. With such sources, it makes little difference whether the driven part of the machine is light or heavy. The sounding areas can be made of steel, brass, wood, aluminum, cardboard, or almost any other material, and the resulting sound is essentially the same.

On the other hand, if one is dealing with sources of "constant force" rather than of "constant displacement", great changes can be obtained by varying the mobility. Forces due to lack of balance are usually fairly independent of the resulting motion. Consequently, the motions can be great if the mobility of the surrounding parts is high, (i. e., mountings which have little weight, or yield easily). Similarly, the vibration can be reduced by decreasing mobility by the use of heavy, stiff parts.

One of the first items in a noise reduction job is to determine if the sources of vibration approximate "constant displacement" or "constant force" sources. This determination indicates the possibilities of quiet-

ing by changing the mobility of vibrating parts.

The most effective way to reduce the movement of a part is to connect it to the vibrating source by a resilient member such as rubber or springs. A resilient mounting of this type is essentially a device for transforming a "constant displacement" source of vibration into a "constant force" type. By allowing the initial vibrator to work against a very soft connection, there is little reaction on the initial source, so that little force is drawn from it. This small force is in turn applied to the body at the other end, and if static deflections are sufficiently large, this force is essentially of the "constant force" type. Hence the mobility of an object which is resiliently mounted will have a large effect on its motion, and quieting can thus be achieved. *Fig.* 2 shows a blower mounted on rubber to reduce noise.

2. REDUCTION OF RADIATION RESISTANCE—Radiation

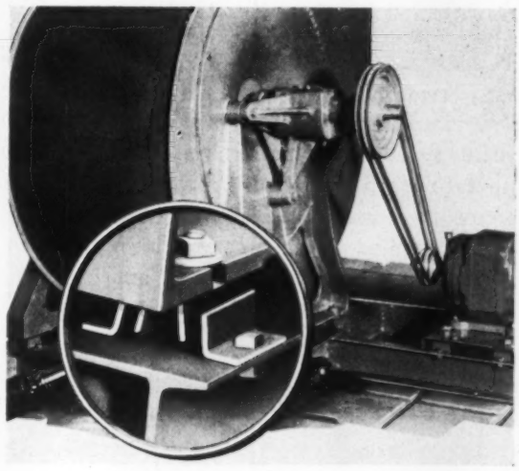


**Fig. 2—By mounting blower on rubber, its vibration is not transmitted to floor and noise reduction is achieved**

resistance is a term taken over directly from electrical terminology. It is well known that sound is radiated from vibrating objects, and that this radiated energy must be drawn from the source which drives the vibrating object. Accordingly, there is a greater resistance to the motion of the vibrator than would be the case if the vibration took place in a vacuum so that no sound energy were radiated. Since this increase of resistance can be measured easily, it is practice to speak of the amount of sound radiated in terms of this increase of resistance, which is called "radiation resistance". In common language, the radiation resistance of an object is simply a direct measure of the sound energy radiated from it. The greater the sound energy radiated, the greater the resistance to motion of the radiator. Hence, if we can reduce the radiation resistance of a vibrating object, we can reduce noise. *Fig.* 3 shows the effect on radiation resistance of objects of the ratio of the wavelength of sound to the dimensions of the vibrating area.

Ordinarily, the various parts of a sounding object are vibrating in different phases, and the effect of the various areas can be computed by taking the square root of sum of the squares of the pressures from the component areas. Reducing the radiating surface by a factor of 2 usually decreases the sound pressure by about 30 per cent.

In general, it can be said that sound can be reduced materially by reducing the radiation resistance if the dimensions of the vibrating parts can be made smaller than the wavelengths of the sound being radiated. At 1000 cycles, the wavelength is about one foot and at 100 cycles, about 10 feet.

3. ENCLOSURE—One of the most effective ways for reducing noise is to place an enclosure around the source, or the observer. For best results, such an enclosure should *not* be made of sound absorbing material. Instead it should be made of a very poor sound absorber. The explanation for this apparent paradox is that the action of such an enclosure is not obtained by sound absorption. Let us consider what we mean by a sound absorber.

*Fig.* 1 shows a section of wall covered by a layer of sound absorbing material. The very best sound absorbers are soft, porous materials, such as hair felt, rock wool, cellulose fibers, cotton, etc. Assume now a section of plane sound wave of pressure, $p_o$, incident upon the material. Most of the pressure is transmitted directly through the porosities of the material but a portion of the pressure is dissipated in forcing air through small intricacies of the material. The wall is practically a perfect reflector for sound, so the wave returns through the material and suffers another diminution. But after passing through a couple of inches of the best sound absorber, the wave will still have about 88 per cent of its original pressure. This much reduction is of little or no practical importance. Sound absorbers have their uses, and these will be considered presently, but they are not suitable materials for enclosures.

It often happens that the noise is increased rather

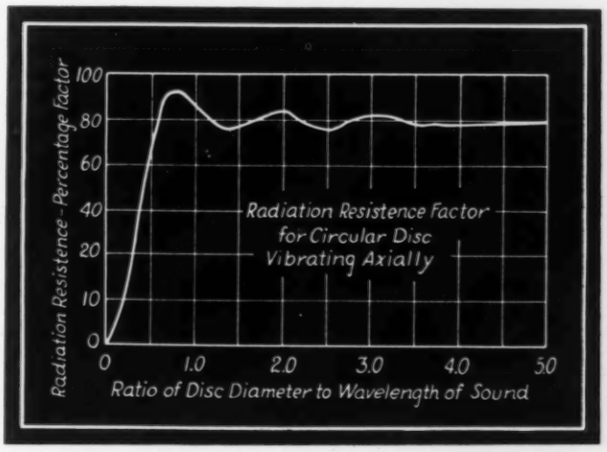



**Fig. 3—Effect on radiation resistance of objects depends on ratio of wave length of sound to size of vibrating area**

than decreased when an enclosure is placed around a machine. This is due to the fact that the enclosing shell is not driven by the sound pressure of the air, but is driven by mechanical contact with the machine.

If an enclosure could be hung on a "sky hook" so that mechanical transmission to it would be nil, then pure acoustic driving would result. In practice, there is a dearth of sky hooks, and it is necessary to mount the enclosure on the machine, or on something adjacent to the machine. In such cases, the vibrational force transmitted mechanically is often greater than that transmitted acoustically. If the mechanically transmitted force approaches the "constant displacement" type, as is often the case, the enclosure simply adds to the sound radiating surface, and the noise is increased.

4. Acoustical Absorption — Acoustical absorbent materials have a most vital place in architectural

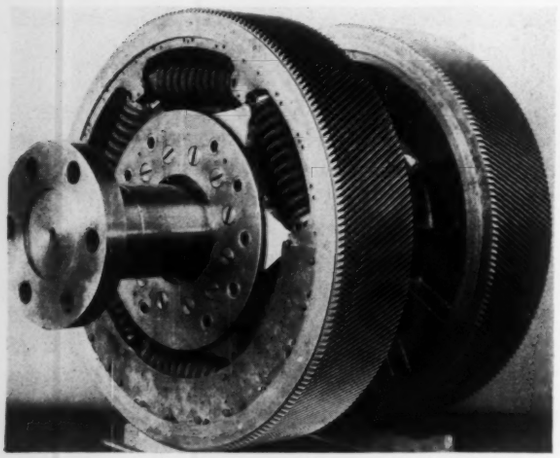


**Fig. 4—Noise from large marine gear is reduced by building springs in hub to absorb shock and vibration**

acoustics, and the improvements obtainable by them are almost unbelievable. In machine noise reduction they play a far less conspicuous part, although they have valuable applications. Even in architectural acoustics, the essential improvement is not attained by reducing sound level. While acoustical treatment of rooms usually reduces the average sound level the real improvement is due to the elimination of persisting multiple reflections or reverberation which may so "hash" the sound that speech is practically unrecognizable, and music is much impaired. In most machine noise which is more or less continuous, these multiple reflections are not important close to the machine where the noise is greatest, and their presence at other points is manifested chiefly by a modest increase in sound level.

Sound absorbing material can be very effective for sounds in tubes and ducts. Modest effects can be obtained in enclosures which initially have very little absorption. As a means of reducing machinery noise, sound absorbing material is of very little value unless it can be applied under very favorable conditions.

5. Mechanical Damping Resistance — Mechanical damping resistance is the result of friction between parts, or internally in materials when they vibrate. The latter is called hysteresis loss. The energy required to overcome this friction appears as heat. In most materials this resistance is small, but in viscous materials, such as tar-like substances, rubber, fluids, and sometimes gases it can be used to obtain mechanical resistance. In most instances there is ample force available to overcome the friction which accompanies the extremely low velocities of audio frequency vibration. (The velocities are usually measured in thousandths of an inch per second, because of the very small displacements). There are two special cases, however, in which damping is of particular consequence.

The phenomenon of resonance is too well known to require discussion here. When mass-stiffness combinations are such that one of the natural frequencies of the system is close to the frequency of a driving force, large movement results. Increased damping greatly reduces the magnitude of such resonance peaks. Demonstrations of this striking effect are so well known that one instinctively thinks of this as a powerful means of quieting. Certainly, this means is effective in cases of resonance, but instances where it can be applied to machinery quieting do not occur nearly as frequently as might be expected. Use of springs in a large marine gear for damping vibration is shown in *Fig.* 4.

### Damping Effective for Certain Noises

If an oscillating system is given a displacement and allowed to vibrate of its own accord, the so-called transient dies away much faster if there is more damping resistance. Usually such transients are not nearly as common as continuous driving during which damping resistance plays no part. If one pounds on an automobile panel with his fist, the resulting vibration dies away more quickly if the panel has been treated by the application of damping material. On the other hand, it appears that on the road, the driving forces are essentially continuous, and little difference is noted whether the panels are damped or not.

In summary, it is found that mechanical damping resistance can effectively reduce only resonances and transients. If these happen to be the troublesome types of vibrations, damping is useful. Otherwise, it is of little consequence.

6. Greater Accuracy of Parts — Machine parts which are loose, badly out of balance, or poorly built are inclined to knock and rattle, and in such cases worthwhile reductions can be obtained by tightening, balancing, and better workmanship. On the other hand, reduction of production limits and tolerances is by no means a cure-all for noise. It may be a very costly manufacturing job to reduce a tolerance from

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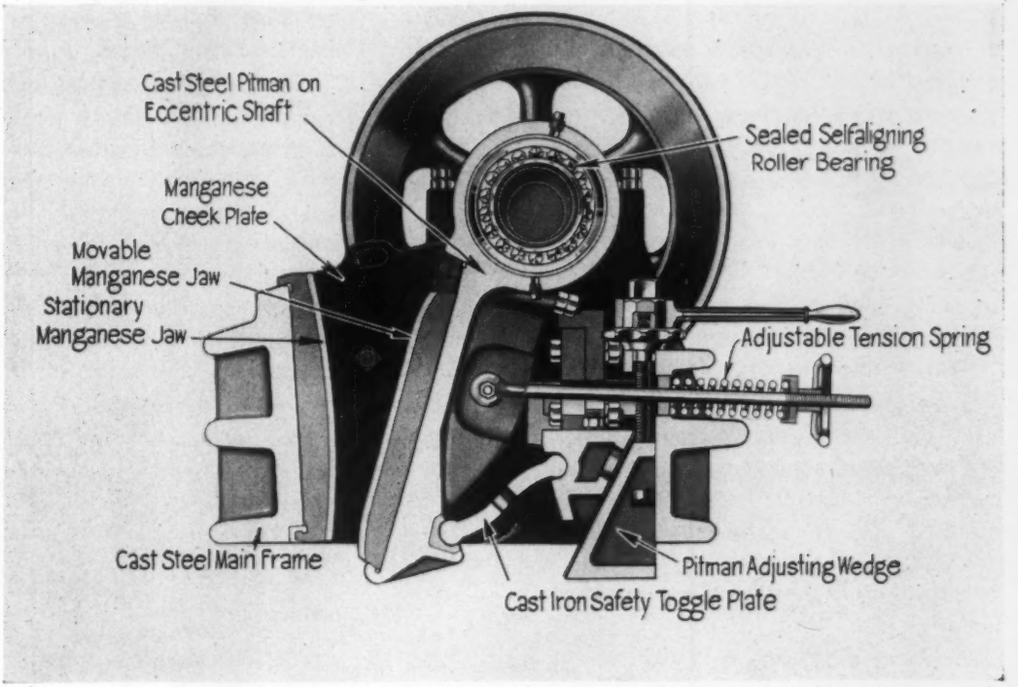



**Fig. 1—Section through jaw-type rock crusher, showing main features of materials and design making possible continued operation under terrifically hard service. Rocks entering wide mouth of the jaws are broken smaller and smaller as they settle through the narrowing throat**

# It Has to Be Rugged to Crush Rocks!

**By Kenneth Lindsay V.P.**
and
**Harold Pollitz Ch.' Engr.**
Iowa Manufacturing Co.

BECAUSE of the extremely severe conditions to which they are subjected in service, portable rock crushing and screening units must be rugged and shockproof. Selection of materials of construction and the design of parts, drives and bearings are problems in the solution of which practical experience is of great value.

The portable straight line plant whose crusher units are dealt with in this article consists of a grizzly screen for removing boulders more than 10 inches in diameter; a sand and grading screen; roll and jaw crushers and conveying equipment, all mounted on rubber tires for ease in transportation. For portability the unit must be as compact and light as possible. For crushing and handling the material it must be strong and rigid. Incidentally the largest portable units weigh about 60,000 pounds.

Material is fed by conveyor or by power shovel into a hopper with regulated flow onto the screen. The latter first separates sand and then sizes the rock into two groups. The rocks smaller than 3 inches go to a roll crusher, *Fig.* 2, which reduces them to ½ to 1-inch pieces, as set. Rocks from 3 to 10 inches go through a jaw crusher, *Fig.* 1, where they are reduced to less than 3 inches for handling by the roll crusher.

The jaw crusher, which is driven at 250 revolutions per minute, consists of a fixed and a movable jaw plate mounted in V-position with the movable plate fastened to an eccentric drive shaft. The rock is crushed progressively as it moves down in the V-jaws. A counterbalanced flywheel counteracts eccentric "throw" of the shaft, thereby decreasing "pounding" load on the bearings.

The forged and heat treated eccentric shaft is of SAE 3140 chromium nick-

el steel. It is step cut to assure maximum rigidity and strength. Shaft and eccentric are mounted in oversize, double row, totally enclosed, self-aligning, spherical roller bearings. On account of the highly abrasive rock dust and heavy shock load, special care has been taken in the design of bearings and seals. Each bearing is provided with labyrinth grooves and flinger disks so that the lubricant must turn fourteen corners to escape and dust must turn the same number of corners to enter.

### Steel Castings Stand the Shocks

Two important parts of the crusher shown in *Fig.* 1 are the base or main frame and the one-piece pitman or frame supporting the movable jaw. These are annealed electric steel castings with heavy reinforcing ribs to withstand the terrific crushing shock of hard materials. Both front and back inside surfaces are machined to insure good fit and alignment.

The corrugated crushing jaws and the cheek plates which form the side of the jaw opening are of 12 to 14 per cent manganese steel. As installed, this material is relatively soft but the peening action of crushing changes it into a hard, tough, wear resistant material, able to withstand the impact shocks and wear of cracking boulders, stone or "niggerheads." Both jaws and cheek plates are reversible so that when the face corrugations, which hold the stones from slipping, wear on the lower half they can be reversed to provide increased life.

The wedge bolts which hold the jaws and the cheek plates, are of high tensile, heat and wear resisting nickel steel. As the jaws get hot in operation a bolt with a high yield point is necessary to permit takeup. Holding and adjusting wedges are tapered to permit takeup from wear or for adjustment, as well as to take care of slightly different lengths of jaw plates.

For protection against extremely hard rocks and tramp iron, two safety features are built into these crushers. Each flywheel has three steel shear pins in the hubs which, upon shearing, release the drive and the momentum of the flywheels. In addition the crushers have an S-shaped toggle plate which holds the opening of the pitman jaw in position. This is of cast iron, with openings cast in the center to weaken it so that the brittle iron will break under an excessive overload. Shear pins and toggle plates are easily, quickly and economically replaced.

The roll crusher for final sizing, as indicated by *Fig.* 2, consists primarily of a pair of rotating manganese steel rolls or shells. These are 30 inches in diameter and 18 inches wide. One is mounted on fixed bearings, the other is held in position by two chromium-vanadium springs of 1⅝-inch rod.

Double row tapered roller bearings support the roll shafts. The pillow blocks for one shaft are stationary while those for the other shaft are loosely mounted and held by springs. Bearings and housings move with the shaft as the roll pinches rocks and shifts on the shaft. Thus the bearings are in fixed alignment at all times with the shifting shaft.

Roll shafts are SAE 3140 chromium-nickel steel forgings to give maximum strength with minimum weight, while the shells are manganese steel castings. It formerly was the general practice to provide ribs on these shells to facilitate the nipping action of the roll on the stone. However, it has lately been found that grooves or corrugations serve as well, and have the advantage of wearing down with the roll shell instead of wearing smooth as do the ribs. This change in design thus increases the life of the shell.

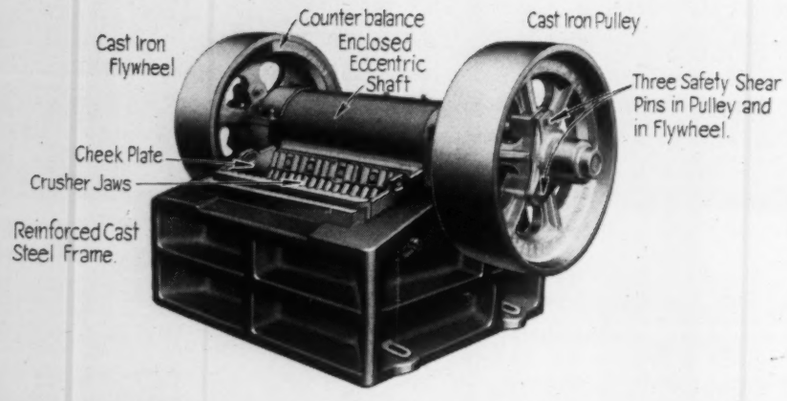
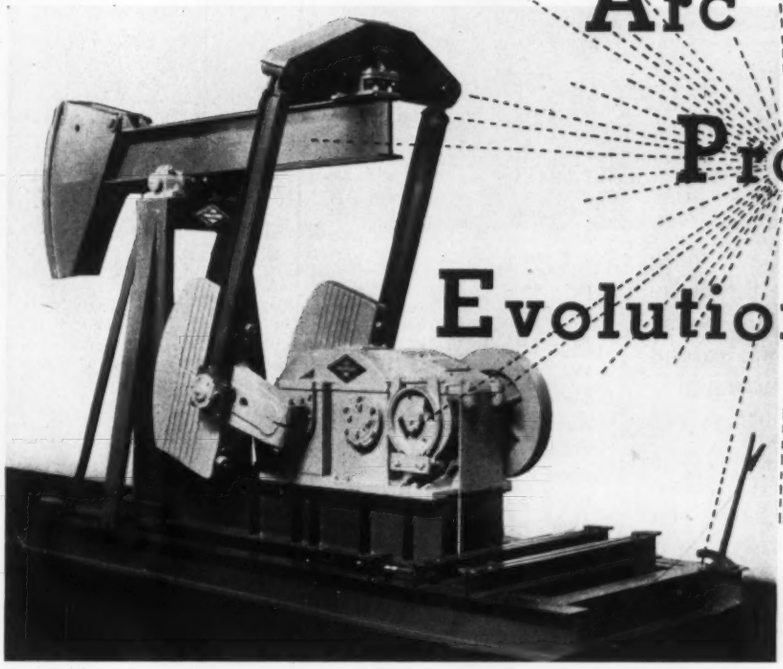



**Fig. 2—General view of roll crusher for further reducing rock, such as has been through the jaw crusher. Drive to rolls is by enclosed, heat-treated roller chain from countershaft gear, over one roll sprocket as over an idler, thence around the other roll sprocket**

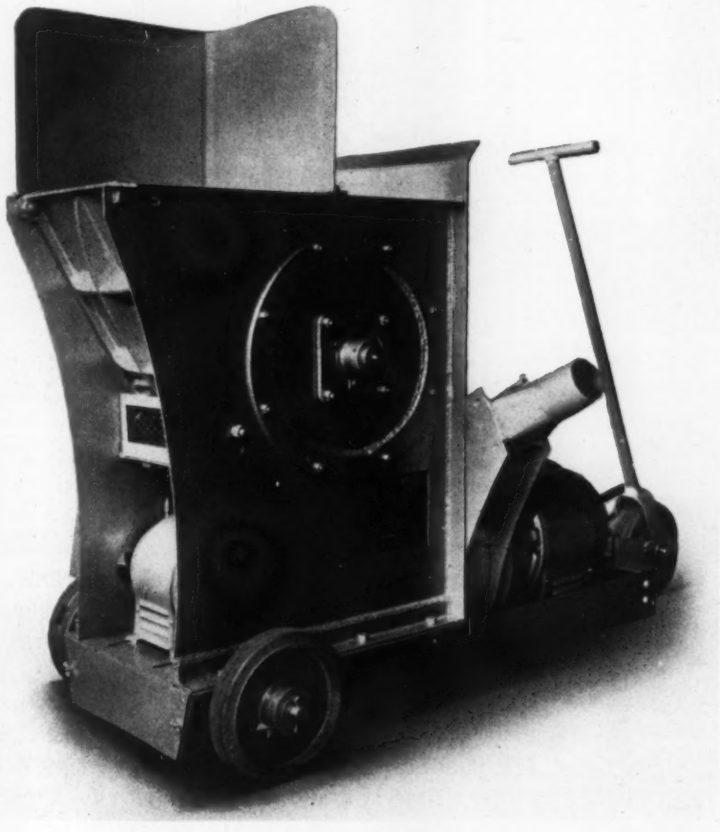
# Arc Welding Promotes Evolution in Design



By E. C. Powers

Fig. 1—Arc welded oil pumping rig shows liberal use of structural shapes for strength, light weight and low fabrication cost

Fig. 2—By redesigning this portable ice crusher and slinger for welded plate construction, its weight was cut over 40 per cent



BECAUSE of the possibilities which it offers for the exercise of constructive ingenuity, the subject of arc welding is being studied with enthusiasm by an increasing number of engineers and designers in the machinery building industry.

No one realizes better than these designers that complete understanding of a machine is based upon com-

*WIDESPREAD interest in welding as a factor in the machinery building industries is stimulated by the award program of the James F. Lincoln Arc Welding Foundation, of which Mr. Powers is assistant secretary. Of $200,000 total, the Machine Division is assigned $50,600 to cover 108 awards. Here is an opportunity for designers to profit by expression of original ideas for welded designs—possibly along lines suggested by this article*

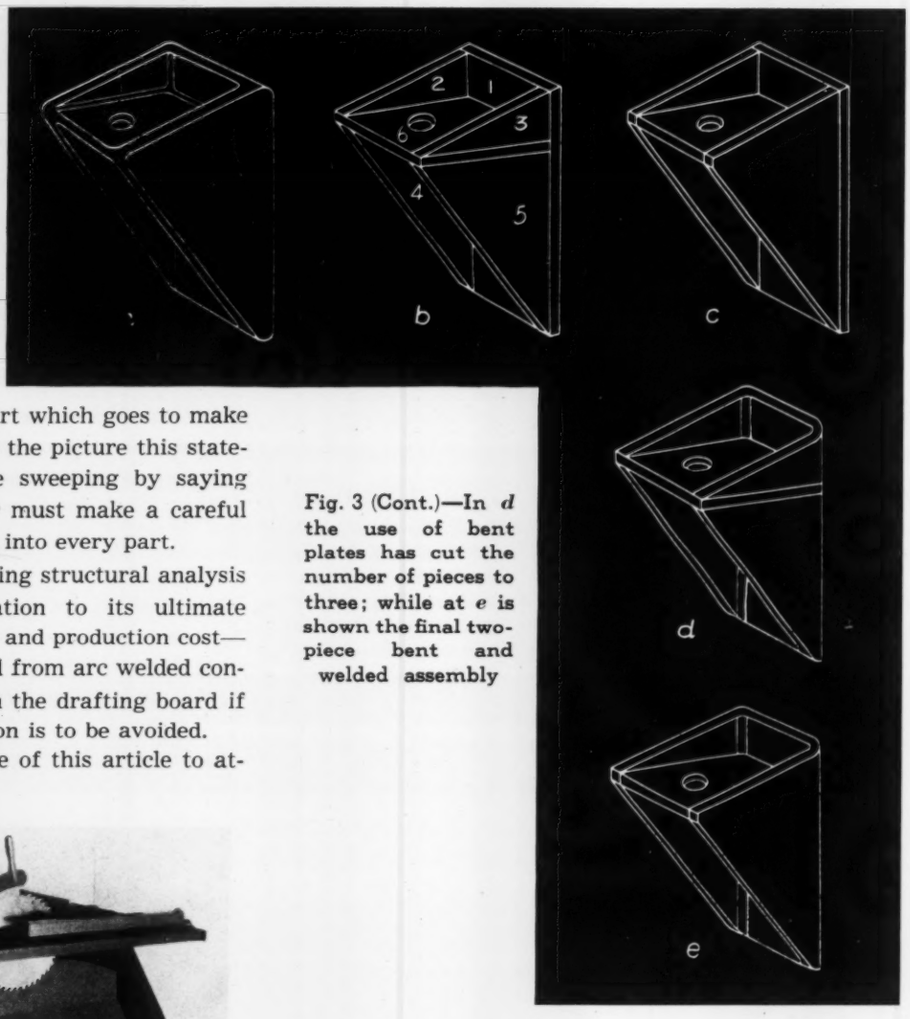



Fig. 3—First design was *a*: *b* is welded from six pieces; and *c* shows reduction to four pieces

Fig. 3 (Cont.)—In *d* the use of bent plates has cut the number of pieces to three; while at *e* is shown the final two-piece bent and welded assembly

plete understanding of every part which goes to make it up. When welding comes into the picture this statement can be made even more sweeping by saying that in such cases the designer must make a careful study of every element entering into every part.

It is only through this searching structural analysis of each part—with consideration to its ultimate strength, durability, appearance and production cost—that full benefits can be attained from arc welded construction. All this must start on the drafting board if cut-and-dry shop experimentation is to be avoided.

It certainly is not the purpose of this article to attempt to make every designer and draftsman a welding expert. Even the best of them will do well to work closely with the experienced men in the welding department of their own company, with applications engineers associated with manufacturers of welding equipment or with a recognized consulting engineer in the field of welding. Only by such a meeting of minds can the best results be achieved economically and without loss of time.

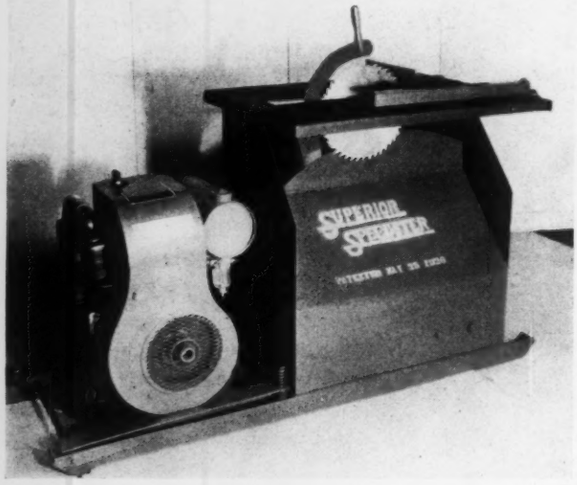
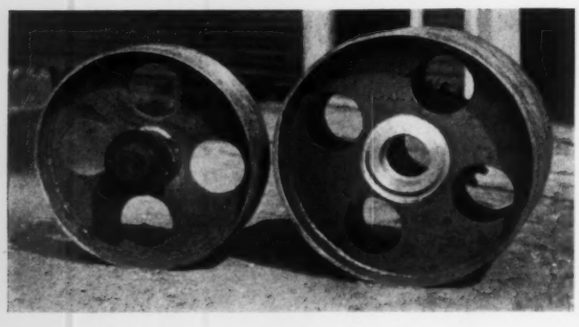



Fig. 4—Portability of this circular saw unit is helped by its welded plate design

Fig. 5—Single and double webbed steel wheels are of flame-cut plates—arc welded



As concrete examples of what can be accomplished through the cooperative effort of mechanical engineers and welding engineers, consider the several and decidedly varied types of machines depicted by the photographs which appear with this article. While in all of these cases, utility and durability are of much more importance than appearance, it is a fact that these arc welded assemblies of steel plates and shapes —planned though they are primarily for simplicity and ruggedness—are definitely good looking machines in their own distinctive way.

Before considering these machines, let us study the evolution of the typical arc welded part shown diagrammatically in *Fig.* 3. This part might well be either a base, a bracket, or other part for a machine,

the design of which is clearly depicted by *a* in the diagram. While design *b* does appear rather absurd, it actually was the initial form that the item assumed when fabricated from cut steel plate by arc welding. On account of the number of individual pieces of plate involved, cost of cutting and welding was too great.

Design *c* was the result of a successful effort to cut down the number of pieces, and for a flat plate proposition is a sensible design. Next comes design *d* which introduces the idea of reducing the number of pieces and the amount of welding by making use of bent plates. This idea—with the help perhaps of more powerful bending equipment—bears final fruit in design *e*, involving only two pieces and welding only to the extent of fastening in the internal web or partition. Contrast this with the six pieces and extensive welding involved in design *b*, or even with the four pieces involved in the really practical design *c*. Note the fact that the more sensible and economical the design, the better is its appearance.

The machinery base shown diagrammatically in *Fig.* 6 is typical of a successful effort to reduce weight and cut cost through welding. Worthy of note here is the manner in which the ribs or webs in the ends of the supports are made to line up with the web of the side channels—also the manner in which the webs of the cross members have been carried directly into the foundation support by matching ribs in the channels.

Now to get back to the complete machines. In that

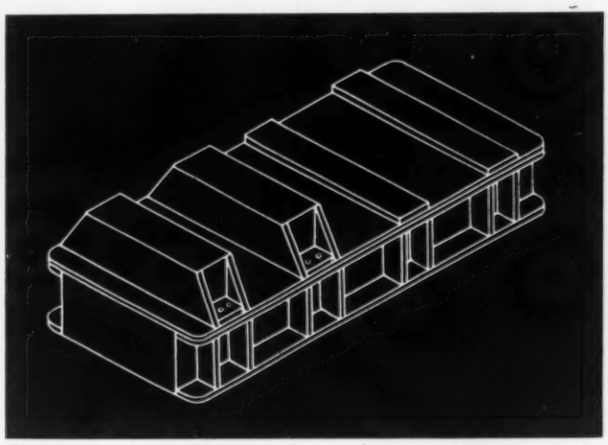


**Fig. 6—End support ribs line up with side channel ribs and cross member webs are carried into welded foundation**

one depicted in the heading of this article we have an example of something where rugged dependability must be coupled with reasonable weight, and where in some locations field fabrication may be necessary. This is an oil well pumping rig. As the illustration clearly shows, generous use has been made of standard structural shapes which give the required strength, at the same time reducing the amount of cutting and welding to the minimum. Where plates have been used, it is obvious that study has been given to attaining economy in their cutting and welding within the bounds of sound mechanical considerations.

The portable machine which appears as *Fig.* 2 is called an ice crusher and slinger. It is used for refrigerating vegetables, etc., in freight cars by covering the cargo with a blanket of finely pulverized ice. As compared to a previous design, this welded model represents a saving in weight of over 40 per cent.

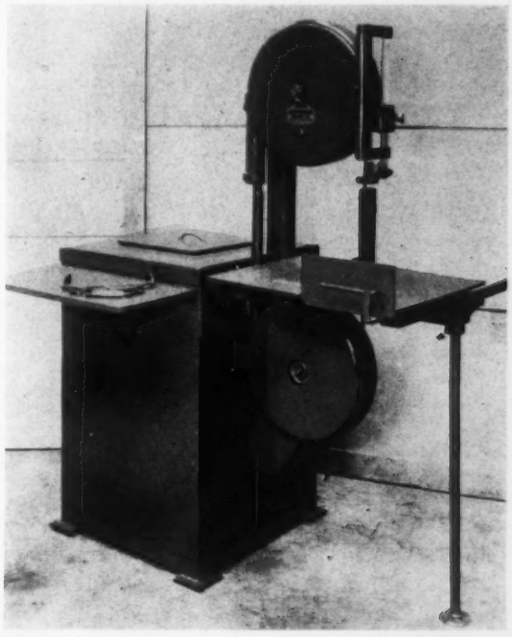


**Fig. 7—Welded construction has eliminated useless dead weight from this dry ice band saw**

The circular saw, *Fig.* 4, as is indicated by its unit drive by a small gasoline engine and by its "sled runner" skids, is a machine designed to be moved about and placed where work of the moment demands. Under these conditions of use, the saving in weight attained by the use of relatively thin but stiff steel plates, arc welded to give rigidity, is of importance.

The arc welded steel wheels shown in *Fig.* 5 illustrate two applications of a similar welding technique—the wheel at the left being of single web type, while the heavier one at the right is double webbed.

And finally we come to *Fig.* 7 which is a dry ice band saw. While designed for permanent location, the elimination of dead weight represented by its welded construction means saving in initial cost, saving in cost of setting up, and reduction of floor load.

In considering any of these designs bear in mind that, regardless of how large or complex the machines may be, they are after all merely a grouping of a number of details. Therefore their success is based upon the careful thought which engineers and technicians have put into the design and fabrication of every detail.

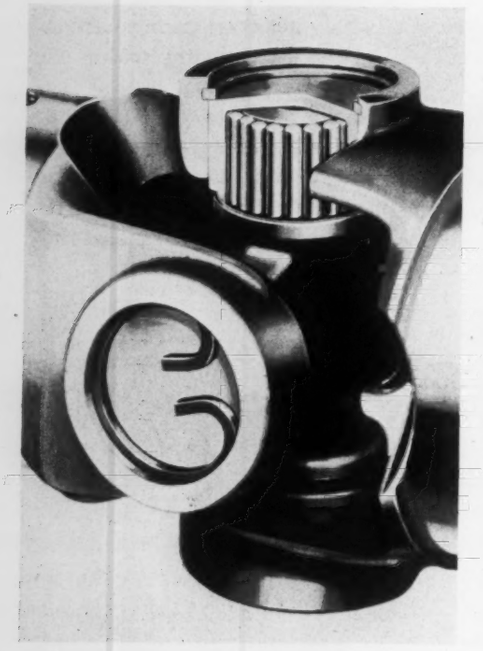


Fig. 1—Snap rings, inexpensive and easy to apply, are thoroughly dependable in many vital spots such as those above

# Security of Fastenings Is Achieved By Ingenious Means

By Guy Hubbard

ACCORDING to a much quoted legend, a horseshoe, a horse, a king, a battle and a kingdom all were lost in quick succession because a horseshoe nail had failed to do its duty. While nothing quite so sweeping has as yet been charged against a bolt, screw or nut, the possibilities for disaster as the result of premature loosening of a simple mechanical fastening are tremendous in this age of machinery.

Realizing this, inventors have been concerned ever since the early days of machinery with problems of developing fastenings which could readily be removed when desired but which would not "remove themselves" as a result of the strains, vibration and gradual flow of metal which occur when machinery operates over long periods under service conditions.

Although this quest still goes on, and will go on for a long time to come because new ways to solve old problems will continue to be sought, there are now available to designers many commercially successful means for insuring secured fastenings. As a matter of fact manufacture of these items now constitutes a large and rapidly growing division of the fastenings industry—and one which to no small degree owes its prosperity to the active and brilliant sales promotion methods followed by those engaged in it. Consider, for instance, the effective manner in which the advantages of spring washers are being driven home to designers, builders and users of mechanical products through cooperative advertising.

This article is not an attempt to cover all the systems for "securing" removable mechanical fastenings, nor is it even an attempt to do more than to touch lightly upon a few of many worthwhile systems. It would be entirely possible to devote an entire book—and a very interesting and instructive book at that—to the design, selection, and functioning of the helical spring washer. The same is true of castellated nuts and cotter pins and standard lock nuts—the specification of which has become almost instinctive with designers and draftsmen, whether they be working on delicate mechanisms destined to lead sheltered lives or on road machinery destined to meet with about every indignity that machinery can withstand.

Speaking of spring locking elements immediately

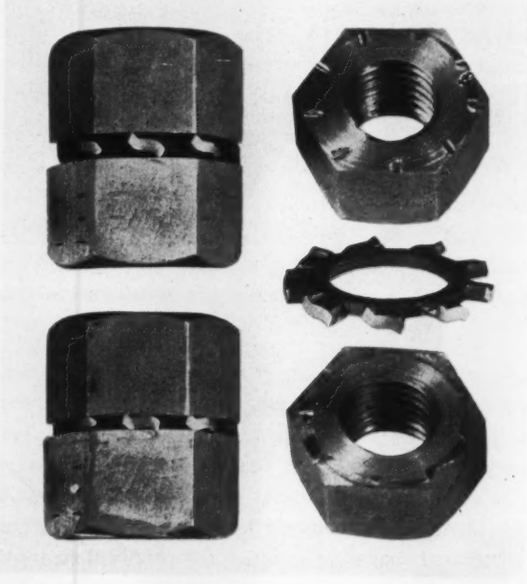


Fig. 2—When compressed, this multiple-tongue washer combines spring tension with positive "bite"

brings to mind a very simple and effective type of fastening known as the snap ring. This is an old idea but it is such a good one that it finds uses in vital spots in automobiles. Such an application is shown clearly in *Fig.* 1. The illustration depicts clearly the simple preparation required for the use of these spring snap rings. While readily removable by means of a pair of pliers, they are in "for keeps" as far as exigencies of service are concerned.

Live spring action is the key to success of a great many locking devices. In fact it is the basic factor in the action of every type considered in this article. On that account modern improvements in steel and in heat treatments for developing permanent spring characteristics have had a lot to do with making commercially successful what otherwise might be only good ideas on paper.

A multiple-tongue type of lock washer is illustrated in *Fig.* 2, showing exactly how this washer is used and how it achieves its locking effect. It will be noted that

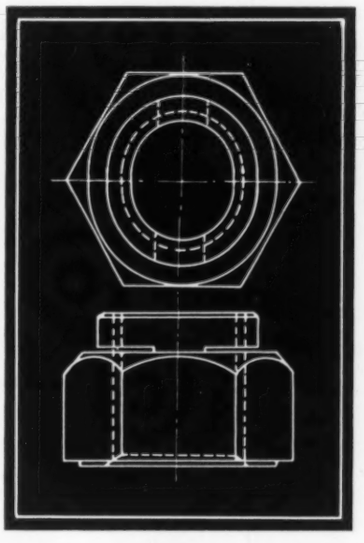


**Fig. 3 — Lateral deformation of a partially severed crown, followed by suitable heat treatment, develops an oval spring ring which effectively holds this nut against vibration — through clamping effect on bolt threads**

the spring tongues have been formed so that when flattened down under pressure their edges bite into nut and work—the tongues at the same time exerting powerful spring tension that maintains the lock. Approximately one-third of a turn is required to effect the lock after the surfaces contact the edges of the tongues and only by a powerful and deliberate pull on a wrench can the grip be broken. Of the many places where these washers are used successfully it is necessary to mention only vibrating screens and rocker arm assemblies of aircraft engines. Various other arrangements are available, including internal tongues, combination internal and external tongues and dished-shapes to go under countersunk heads.

The drawing, *Fig.* 3, shows a patented design in which the spring tension locking is integral with the nut. This is a one-piece, heat-treated, milled-from-the-bar nut in which hex size, thickness, washer contact face, countersink and thread are all to standard

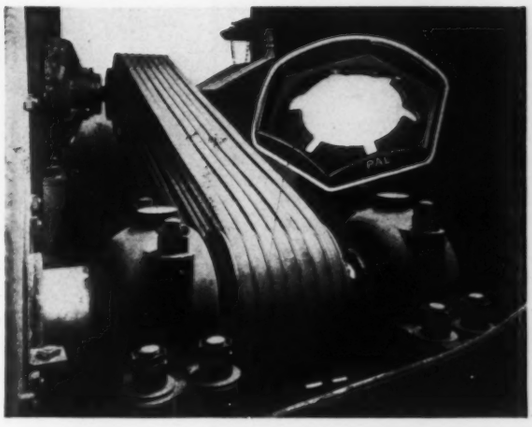


**Fig. 4—Spring nut locks standard nuts by face pressure combined with thread gripping**

nut specifications. The cylindrical section at the top is similar to that on a crown castellated nut but smaller in diameter. At its juncture with the hex section two parallel slots have been cut in part way only, leaving two solid supports. The crown is then compressed to the oval form clearly shown in the drawing. The nut is then heat-treated to give the compressed crown the permanent spring characteristics upon which its action depends.

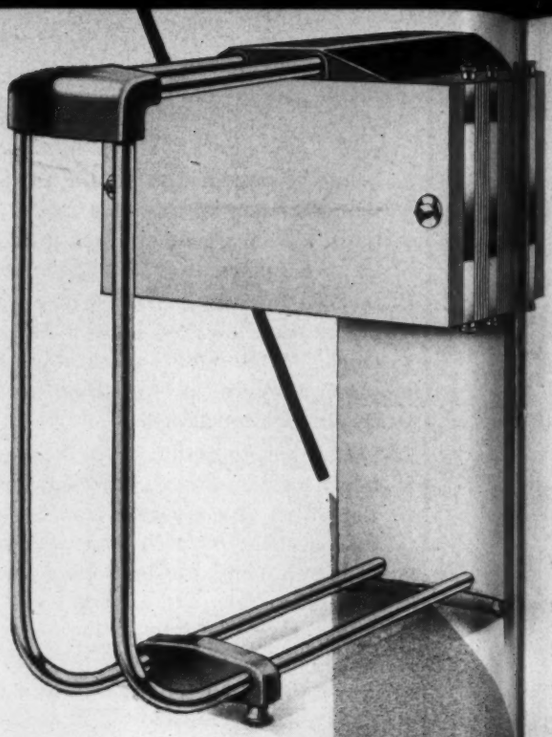
This nut spins on freely until the end of the bolt encounters the threads in the oval crown. The wrench then comes into action to force the bolt into the crown which thereupon is sprung back to its original shape thus developing a grip on the thread which resists vibration, shocks and strains regardless of whether bolt stress is at maximum or zero.

And now we come to *Fig.* 4 which illustrates the design and one of the many applications of an ingenious improvement on the conventional lock nut. This nut is pressed out of sheet steel and hardened and tempered after forming. Its "working members" are the arched multiple spring jaws formed to the true pitch of the bolt thread.

Following tightening of the regular nut this sheet steel nut is spun on with the fingers, open side out as illustrated. Upon contact with the top of the lower nut it is given a quarter turn more with a wrench. While the body of the lock nut then actually moves no further along the bolt, its jaws do continue to follow the bolt thread. This causes them to flatten slightly which exerts strong spring pressure against the top of the regular nut. At the same time these jaws close in around the root of the thread, gripping the bolt like the jaws of a chuck. Thus two separate locking actions are combined to hold the nut tight.

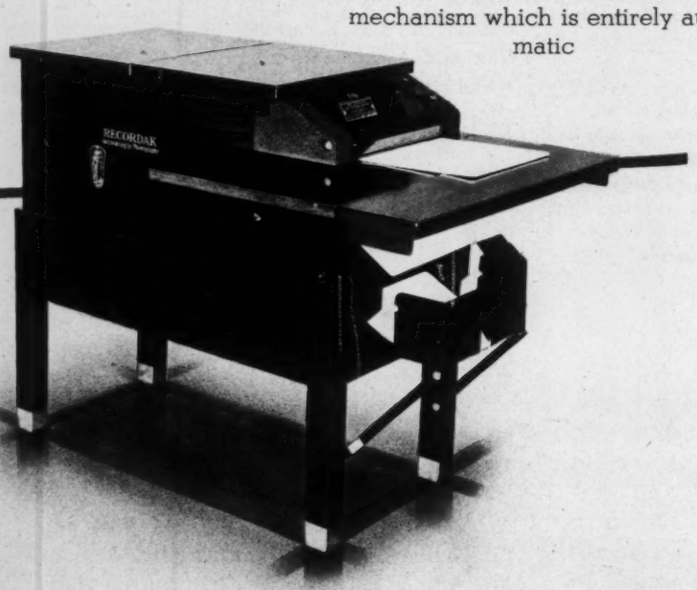
Credit is due the following companies for illustrations used herewith and for cooperation in the preparation of this article: The Cayouette Products Co.; The Nordberg Mfg. Co.; The Palnut Co.; The Spicer Mfg. Co.; the Spring Washer Industry and Thompson-Bremer & Co. Still other systems of locking probably will be dealt with in a later article.

Plates of 18-8 stainless steel having a special satin finish are used in the Creamery Package pasteurization machine, right. They are designed to give maximum cooling of heating surface with minimum of flow obstruction



Nickel - alloy table on Yates-American shaper, left, may be tilted, allowing machine to cut bevels and intricate molding with standard shaper knives. One-half horsepower motor drives knives at 8000 to 10,000 RPM by flat fabric belt, minimizing noise and vibration

Small fractional horsepower motor, through series of belts and clutches, drives camera mechanism in the Recordak photographic teller machine, below. Checks are inserted, photographed and a record made of each by mechanism which is entirely automatic

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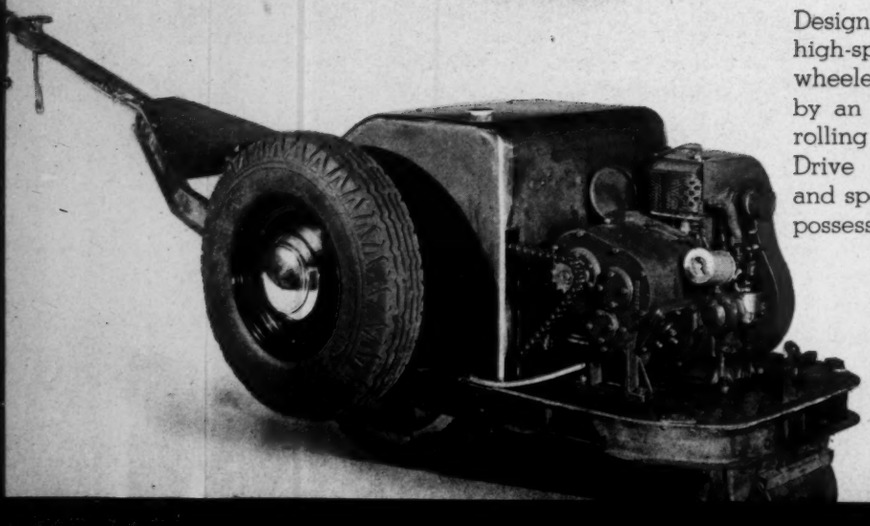
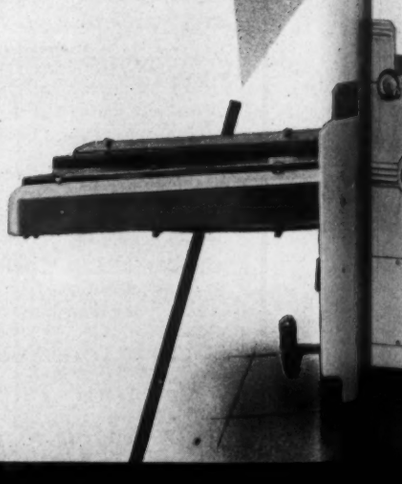


Designed to be towed as a high-speed trailer, the Littleford wheeled roller, left, drives itself by an air-cooled engine when rolling streets or sidewalks. Drive is through roller chain and speed reducing unit which possesses a built-in reverse mechanism



# n Features
# w Machines

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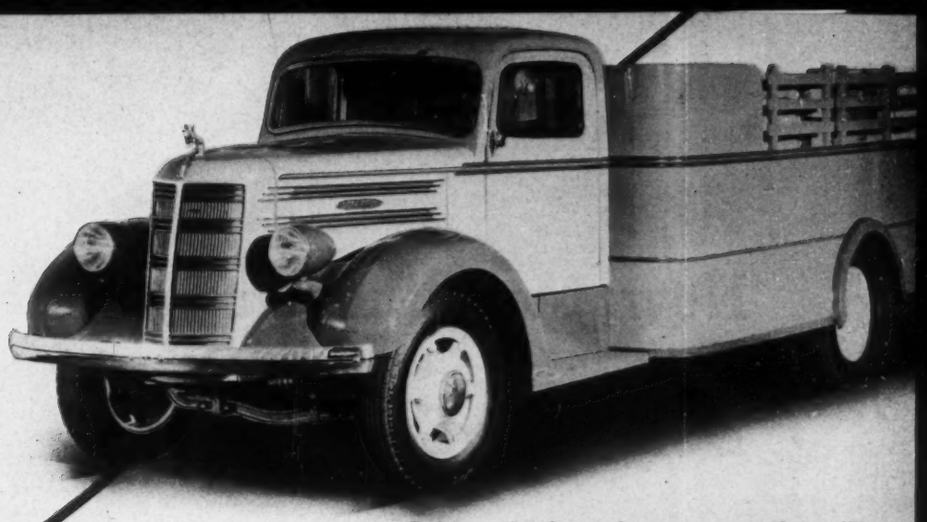
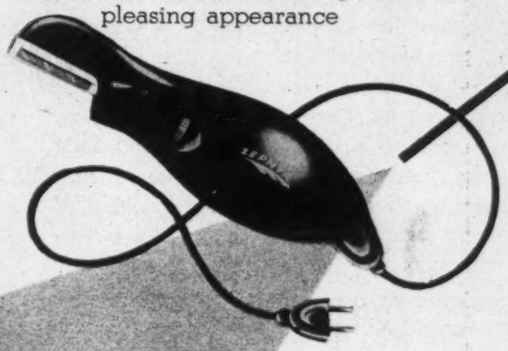


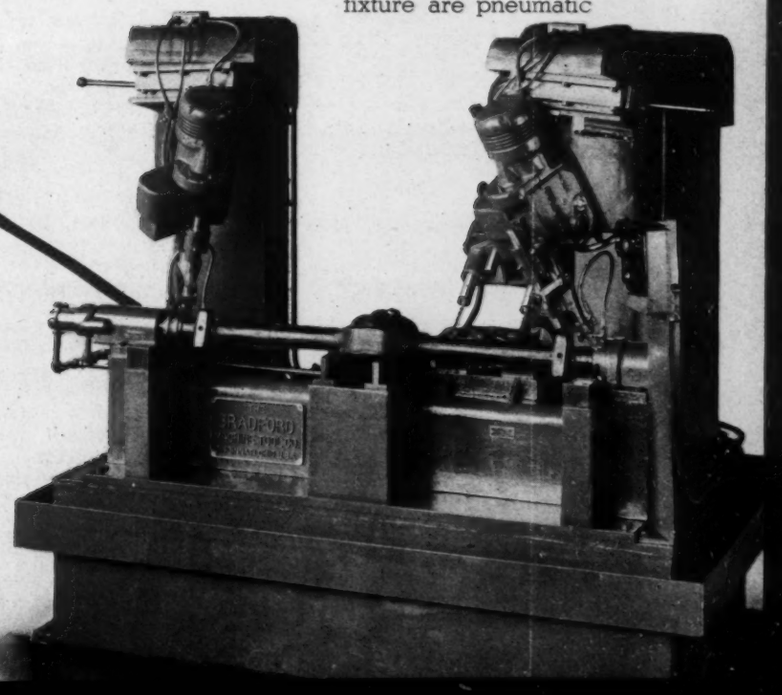
Rubber shock insulators are used at all spring ends in the Mack six-cylinder truck, above. Vacuum boosted, hydraulic brakes insure adequate service and all-metal construction provides utmost in safety design. Drive is through a single plate clutch

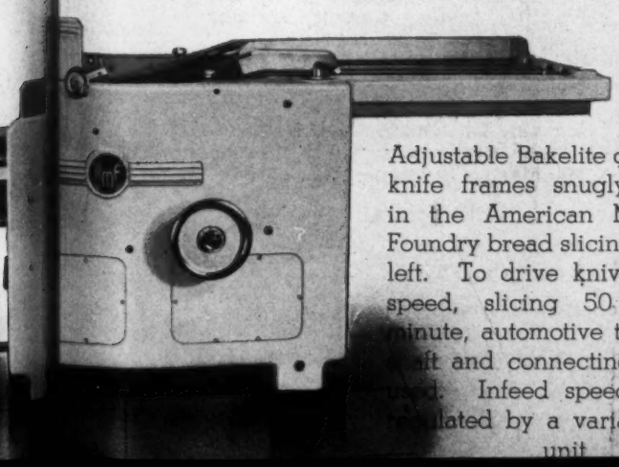
Mechanical complications have been avoided in the Zephyr shaver, below, by mounting cutting head directly in line with shaft of motor. Mechanism is enclosed in brown plastic case, styled for facile handling and pleasing appearance



Timer built into Utility toaster, left, reduces heat after pre-determined time, keeping toast hot until served. Thermostatic control shortens toasting time as machine gets hot, giving a uniform heating to each piece of toast

Constructed almost entirely of welded steel, the Bradford automatic drilling machine, below, features ease of operation. Control and synchronization are effected through built-in limit switches and relays. Automatic clamping and unclamping of the fixture are pneumatic





Adjustable Bakelite guides hold knife frames snugly in place in the American Machine & Foundry bread slicing machine, left. To drive knives at high speed, slicing 50 loaves a minute, automotive type crankshaft and connecting rods are used. Infeed speed is easily regulated by a variable speed unit

# New Machines Indicate Design Trends

FRESHLY painted and with no dirt or grease, new machines leaving the assembly line have a distinctly bright and spotless appearance. After a short period of operation, however, this newness wears off and the machine assumes a dirty and sometimes a rusty exterior. To provide incentive to the user or operator of a machine to keep it clean, designers might incorporate a vitreous finish, stainless steel, or plastics in its construction. These materials, free from corrosion, easily polished and long lasting will inspire the most slovenly workman to clean his machine. The wide prevalence of these materials in the design of food and sanitary equipment, which must be kept spotless, attests to their worth for this purpose.

In addition to the machines on the preceding pages, the following have been recently developed.

### Air Conditioning

Portable air conditioner, York Ice Machinery Co., York, Pa.

### Bakery

*Bread slicer, American Machine & Foundry Co., New York.

### Business

Portable Dictaphone, Dictaphone Sales Corp., New York.
Fluid duplicator, Standard Mailing Machines Co., Everett, Mass.
Carbon coating machine, Haida Engineering Co., New York.
Desk calendar and clock combination, Park Sherman Co., Springfield, Ill.
Office electric vacuum cleaner, Ideal Commutator Dresser Co., Syracuse, Ill.
Communicator, Albertson Co., Toledo, O.
Water cooler, Halsey W. Taylor Co., Warren, O.
*Photographic teller, Recordak Corp., New York.
Money-changing machine, Johnson Fare Box Co., Chicago.

### Construction

Paving finisher, Blaw-Knox Co., Pittsburgh.
Concrete mixer, Multiplex Concrete Machinery Co., Elmore, O.
*Motorized wheel roller, Littleford Bros., Cincinnati.

### Dairy

Bottled milk vender, Kalva Corp., Waukegan, Ill.

### Domestic

Oversize spin dry washer, Apex Rotarex Co., Cleveland.
Rotary ironer, Edison General Electric Appliance Corp., Chicago.
Twin and single tub washers, Dexter Co., Fairfield, Ia.
Radio, Emerson Radio & Phonograph Corp., New York.
Electric range, Kelvinator Corp., Detroit.
*Electric shaver, Zephyr Shaver Corp., New York.
*Four-slice automatic toaster, Utility Electric Co., St. Louis.

### Food

Liquid mixer, United States Stoneware Co., Akron, O.

### Metalworking

Metal dryer, Rochester Engineering & Centrifugal Corp., Rochester, N. Y.
Surface planer, Crescent Machine Co., Leetonia, O.
*Tilting table shaper, Yates-American Machine Co., Beloit, Wis.
*Automatic drilling machine, Bradford Machine Tool Co., Cincinnati.

### Mining

Gold mill machinery, Deister Concentrator Co., Ft. Wayne, Ind.
Breathing apparatus, Mine Safety Appliances Co., Pittsburgh.
Coal crusher, Link Belt Co., Chicago.

### Packaging

Weighing machine, Automatic Scale Co., New York.
Auto-check weigher, B. F. Gump Co., Detroit.
Bag-closing machine, Union Special Machine Co., Chicago.

### Printing

Automatic ejector mold change, Intertype Corp., Brooklyn, N. Y.
Electric print dryer, Duophoto Corp., New York.

### Restaurant

Ice cube cutter, Reinhold Mfg. Co., Detroit.
Table top refrigerators, Brunswick-Balke Collender Co., Chicago.

### Quarry

Excavators, Marion Shovel Co., Marion, O.
Apron feeder, Link Track Engineering Co., Chicago.
Impact crusher, Weaver Mfg. Co., Los Angeles.
Wheeled scraper, Emsco Derrick & Equipment Co., Chicago.

### Textile

Warp float cutter, Hermas Machine Co., Hawthorne, N. J.
Knitting loom, Cidega Machine Shop Inc., New York.
Lacquer printing machine, Tenny & Hoffman Inc., Paterson, N. J.
Piece dye kettles, James Hunter Machine Co., North Adams, Mass.
Rotary rayon cutter, F. J. Stokes Machine Co., Philadelphia.

### Transit

*Truck, Mack Trucks Inc., Long Island City, N. Y.

*Description and photograph of this machine included in pictorial center spread.

# Compulsory Licensing of Patents Has Doubtful Value

MANY objections are being raised by engineers to the proposed bill, H. R. 9259, now before Congress which provides for compulsory licensing of patents. If the bill is passed in its present form severe hardships are apt to be created, grounds for untold litigation set up, and progress in general retarded rather than stimulated.

Instead of a patentee, or the company to which an invention may be assigned, holding the patent rights for seventeen years as at present, the bill makes it mandatory for the patentee to grant a license to a legitimate (loosely stated in the bill) applicant to manufacture and sell under the patent after a period of only three years. Granting of the applications is to come under the supervision of the Commissioner of Patents, with a board of appeals established within the Patent Office consisting of an engineer, an attorney and an economist. Later recourse, if necessary, is to be made through the U. S. district courts.

Complications are easy to foresee. Initiative and incentive will probably be stifled. Furthermore, because a considerable length of time is often necessary (and much expense involved) in successfully developing a patented article or machine, and creating the market for it, great injustice would be done if a compulsory license were granted another manufacturer to produce and sell the product after a scant three-year period. On the other hand there appears to be good in the essence of the bill in that it would eliminate any possibility of the "hoarding" of patents or of their being used to the detriment of the public.

That there are flaws in our present patent laws is unquestionable. That there will be more if the proposed bill goes through without amendment and clarification is highly probable. Therefore, it behooves engineers and their societies, manufacturers and other parties likely to be affected directly by the proposed legislation to study it and take the necessary steps either to have it killed or to help make it a worthwhile measure.

• • •

# Machines and Jobs

FURTHER evidence in support of the claim that machines actually create jobs is forthcoming on every hand. Wm. J. Cameron of the Ford Co. recently pointed out that such a lowly item as a hubcap if made by hand would cost at least twenty times as much as if formed in a machine; and a Ford car on the basis of supposed hand production would cost $17,850. He estimates that at that cost not 50 cars a year would be sold!

The way to sell *more* cars and to create *more* jobs is to develop faster and better production machinery—thus lowering the price of the car to within the reach of a greater number of potential buyers. In no line that we know is the market saturated, so the same reasoning might well be applied to machines for all other classes of trade, agriculture and business.

# Professional Viewpoints

MACHINE DESIGN WELCOMES LETTERS SUITABLE FOR PUBLICATION

*To the Editor:*

PLEASE send me as soon as available, reprints of the article, "General Considerations in Designing Mechanical Springs," by A. M. Wahl, appearing currently in your publication.

I should like three sets of reprints of all four articles which are to appear.

I might say that the article appearing in January MACHINE DESIGN is very well written and instructive.

—G. V. PICKWELL, Spring Engineer
*Delco Products*

*To the Editor:*

We are interested in obtaining six reprints of the series of articles on "General Considerations in Designing Mechanical Springs," by A. M. Wahl commencing with the January, 1938, issue of your magazine. Will you, therefore, please let us know if they are available as soon as possible.

We will, of course, send the correct amount on receipt of your invoice, if there is any charge.

—ELEANOR V. WRIGHT, Librarian
*Chrysler Corp.*

EDITOR'S NOTE—Reprints of the four Wahl spring articles appearing in MACHINE DESIGN from January through April will be available shortly after the last of the series is published, early in April. A nominal fee will be charged for the reprint which will include the entire series.

## Keep Magazine as It Is!

*To the Editor:*

I NOTICED a letter from Andrew Bullmer in your "Professional Viewpoints" column for December in which he suggests that you publish a series of articles on "how things are done in the factory." The idea has much merit, and yet from purely selfish motives (I like MACHINE DESIGN too well as it is) I hasten to murmur, "Please don't!" The task would be so enormous that you could not avoid crowding out some of the very worthwhile material now being published, and that would be a decided loss. Besides, you could hardly avoid rewriting material already available in books, nor could you avoid duplicating articles on current developments that appear in other magazines, both of which would mean loss to your journal. So, by all means, keep MACHINE DESIGN high hat!

—JOHN FLODIN
*Washington*

## Patent Commissioner Encouraged

*To the Editor:*

On January 23, 1937, I suggested to the Commissioner of Patents that the Patent Office print serial numbers of the patents on the back of the cover of the *Official Gazette*. Within two weeks a letter was received from the Patent Office stating that my suggestion would be adopted. On April 6, 1937, I found that the number was being printed as suggested.

This is quick action and should receive the hearty indorsement of all who use the *Gazette*. You can now find any patent number without going through a dozen *Gazettes* for it. I believe the Patent Commissioner should be complimented for his speedy work in adopting this improvement.

—THEO. C. MENGES, Ch. Engr.
*Associated Manufacturers Corp.*

## Color as a Design Aid

*To the Editor:*

A careful study of colors and their possibilities often makes it possible to change the appearance of the product without changing its basic design. The advantage gained is to spread the points between changes in basic design are necessary. Carefully engineered finishes, are thus useful in imparting new touches.

So many finishes are now available that any manufacturer has a very large and varied field from which to make his choices even though all of them may not be suitable for a given product. Proper procedure in making a wise choice consists in listing carefully all consistent possibilities, then choosing from among them the one that will give the most pleasing effect, together with sufficient contrast to what was formerly used.

—JOHN E. HYLER
*Chicago*

# Men of Machines

C. J. McCarthy

SINCE 1917 identified with the design of aircraft, Charles J. McCarthy, engineering manager of Chance Vought Aircraft, (division of United Aircraft Co.), East Hartford, Conn., has now been advanced to assistant general manager of that division.

A graduate of Massachusetts Institute of Technology, Mr. McCarthy has been connected with the Chance Vought organization since 1926 at which time he became engineering executive. In 1930 he was made chief engineer and five years later was promoted to engineering manager, the position he has held until his present appointment. One of his most interesting assignments in the aircraft field was in connection with the design of the fleet of NC-4 flying boats which made the early and notably successful oceanic crossing in 1919.

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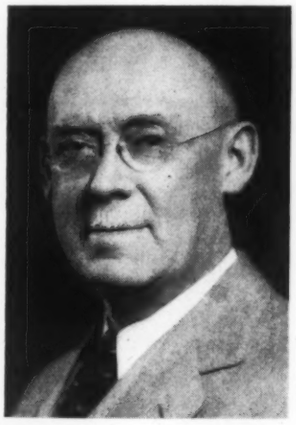


W. N. Barnard

PROFESSOR WILLIAM N. BARNARD, an authority in the field of heat-power engineering, has been appointed director of the Sibley School of Mechanical Engineering of Cornell university. Since 1897, when he graduated from Cornell, Professor Barnard has been a member of the faculty, with the exception of two brief periods. He had been professor of heat-power engineering from 1907 until 1920 when he became head of the department. In 1936 he was named acting director of the Sibley School.

In addition to teaching, Professor Barnard has had professional engineering experience, and has frequently been called upon to act as consultant in the industry. He is also an author of a number of scientific articles and volumes in this field, including a standard textbook on heat-power engineering.

• • •

Gano Dunn

HIGHEST honors in electrical engineering were conferred on Gano Dunn, president of J. G. White Engineering Corp., New York, when he recently was awarded the 1937 Thomas A. Edison medal of American Institute of Electrical Engineers, "for distinguished contributions in extending the science and art of electrical engineering, in the development of great engineering works, and for inspiring leadership in the profession."

Mr. Dunn's early education and inspiration came from his paternal grandfather, Nathaniel Dunn, a graduate from Bowdoin college in Maine in the famous class of 1825, who was a scientist, inventor, college professor, poet and author. Born in New York city in 1870, Gano Dunn graduated from the College of the City of New York in 1889 with a bachelor of science degree, later obtaining his electrical engineering degree from Columbia

university and his master of science degree from C.C.N.Y.

Joining Crocker-Wheeler Electric Motor Co. as draftsman, he was rapidly promoted to vice president and chief engineer. In 1911 with J. G. White, he formed the J. G. White Engineering Corp., of which he became president in 1913.

Credited with more than thirty inventions in design and construction of electrical machinery, Mr. Dunn was the first chairman of the Engineering Foundation. Among his other numerous activities, both national and international, he is former president of United Engineering Societies, American Institute of Electrical Engineers and New York Electrical Society.

♦ ♦ ♦

DELMAR G. ROOS, after a year of consulting work with Humber Ltd., at Coventry, England, has returned to the United States to become vice president and chief engineer of Willys-Overland Motors Inc., Toledo, O.

After receiving degrees both in mechanical and electrical engineering at Cornell, Mr. Roos—in 1911—began his active engineering career in General Electric's research department. From 1912 to 1925 he was with the Locomobile Co. of America, becoming vice president and chief engineer. Subsequently he was chief engineer of the Marmon Motor Car Co., and of Pierce-Arrow and Studebaker. An illustrated biography of Mr. Roos appeared in November, 1933, MACHINE DESIGN, when he was chosen as president of the Society of Automotive Engineers.

♦ ♦ ♦

JAMES W. RICKEY, who has been chief hydraulic engineer of the Aluminum Co. of America since 1907, has resigned. He is succeeded by James J. Growdon, consulting engineer of the hydraulic department.

♦ ♦ ♦

FRANK A. TROXEL, formerly chief engineer, The Jones & Laughlin Steel Corp., Aliquippa, Pa., has gone to Ebbw Vale, Wales, to be chief engineer of the hot and cold strip mill now being operated by the Richard Thomas Steel Co. Ltd.

♦ ♦ ♦

KARL A. PAULY has relinquished his duties as an engineer in the industrial department of the General Electric Co., Schenectady, but as a consultant he will continue his association with the company, with which he has been connected ever since graduating from the Massachusetts Institute of Technology in 1899.

♦ ♦ ♦

DR. GERALD M. COVER has been appointed associate professor of metallurgy at the Case School of Applied Science, Cleveland. A 1924 Case graduate and former member of the faculty, Dr. Cover lately has been connected with the research and operating departments of the National Steel Corp. at Steubenville, O.

♦ ♦ ♦

H. ROSS BELDING has been appointed chief metallurgist at the Carnegie-Illinois Steel Corp., Farrell, Pa.

♦ ♦ ♦

ALBERT M. JOHNSON, chief engineer of the Barnes Drill Co., Rockford, Ill., has been made president of the company. Mr. Johnson has been with the company ever since it was organized in 1907, and succeeds J. E. ANDRESS, who has become chairman of board of directors.

♦ ♦ ♦

T. P. WRIGHT, vice president in charge of engineering of the Curtiss-Wright Corp., has been elected president of the Institute of Aeronautical Sciences, New York.

♦ ♦ ♦

GOEFFREY R. BENNETT has been made general manager of the Toledo Scale Co., and among his other duties he will have supervision over the engineering and manufacturing activities of the company.

♦ ♦ ♦

JOHN G. SHODRON, formerly chief research engineer of the James Mfg. Co., Fort Atkinson, Wis., and his son, JOHN M. SHODRON, who has been mechanical engineer with the Caterpillar Tractor Co., Peoria, Ill., have both been added to the faculty of the mechanical department of Marquette university, Milwaukee.

♦ ♦ ♦

DR. LEO H. BAEKELAND discoverer of Bakelite, has been awarded the 1938 Messel medal by the British Society of Chemical Engineering—the citation being "For outstanding advancement in science."

♦ ♦ ♦

FRANK H. DEWEY was recently appointed president of the Oil Burner institute to fill the unexpired term of CHARLES M. LOCKWOOD, resigned. Mr. Dewey is general manager of the air conditioning division of Gar Wood Industries Inc.

♦ ♦ ♦

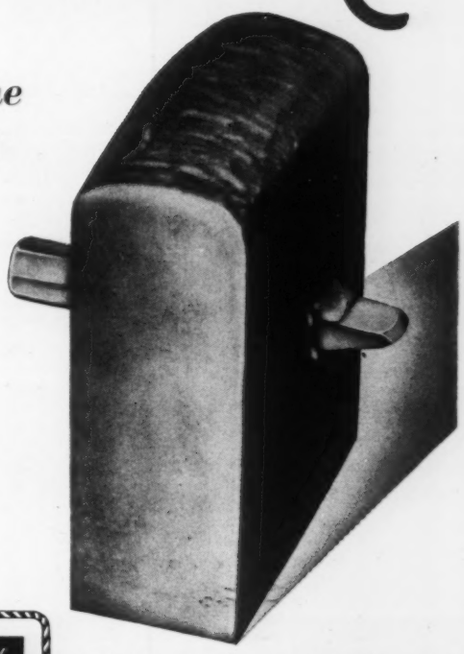
S. K. OLIVER, metallurgist at the Delco Products division in Dayton, O., has been transferred by General Motors to its Electro-Motive Corp. at La Grange, Ill., where he will be in charge of heat treating at the new diesel engine plant.

♦ ♦ ♦

W. E. WHIPP has been elected first vice president of the National Machine Tool Builders' association, succeeding N. A. WOODWORTH, resigned. Mr. Whipp is president of the Monarch Machine Tool Co., Sydney, O.

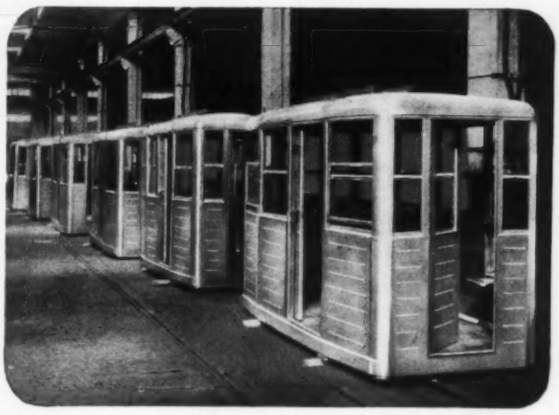
# SIMPLE ARITHMETIC

## ...proves the ECONOMY of the NICKEL ALLOY STEELS



15 x 1 = 15 times Longer life

Multiply the life of a tool and you subtract from the ultimate cost. And a case where tool life was increased 15 times by the simple expedient of Nickel alloy steel in one large industrial plant is indeed a case in point. The chisel driven cold through this loaf-like block of mild steel is simply a dramatic demonstration of its capabilities, but the part of the story that is most interesting to the treasury's watchdog is the fact that it showed a service life 1400% greater than the plain carbon steel type formerly used. The increased strength, toughness, wear-resistance, and shock-resistance obtained with the Nickel alloy steels quickly compensate for the slightly higher initial cost.



100% – 56% = 44% of former weight

Dead weight is a wastrel. It squanders power in many an application, subjects machinery to unnecessary stress, wear and fatigue. But Piaggio & Co. of Genoa, Italy, solved the problem of useless weight in the same way that scores of railroads are now doing. They used stainless steel for these aerial railway cars destined for use in the Italian Alps. Fabricated under license of the Edward G. Budd Manufacturing Co. of Philadelphia, these cars when completed weighed 56% less than the type formerly used. The composition employed was the popular "18-8" chromium-Nickel steel which possesses an unusually high strength-weight ratio.

16 – 15 = 1 Survivor

Plow discs of the type pictured here take a terrific beating from shocks and abrasion. A prominent manufacturer, Ingersoll Steel and Disc Division of Borg-Warner Corp., recently developed a steel for this purpose, having all of the requisite properties for long service life against breakage. Composition is known as "Super-Alloy" and contains from 1 to 1½% Nickel, a fact that explains its unusual endurance. Demonstration of its superiority was recently made when a harrow disc plow came to this manufacturer's attention with 15 of its 16 discs broken. Analysis brought to light that the 1 survivor was made of "Super-Alloy", the composition containing Nickel.

*We invite consultation on the use of the Nickel alloy steels in your equipment.*

# NICKEL ALLOY STEELS

**THE INTERNATIONAL NICKEL COMPANY, INC., NEW YORK, N. Y.**

# Noteworthy Patents

PATENT No. 2,081,456, granted to Charles W. Howard of Franklin, Ohio, and assigned to The Black-Clawson Co. of Hamilton, covers improvements in machinery for waxing paper.

An interesting feature of this invention has to do with removal of cooling water from the surfaces of the waxed sheet as it travels through the machine. This element—which is illustrated by *Fig.* 1, and in which the paper travels downward, that is from left to right in the end view at the left—eliminates entirely the use of suction devices for drying the sheet.

Before reaching this element the paper has passed through a wax tank, where wax or paraffin has been applied to both sides, then through a cooling tank containing cold water or other suitable cooling liquid. Upon entry at the top of the apparatus shown herewith, there is some liquid clinging to the waxed surfaces of the paper in the form of small globules.

These globules are effectively removed within this apparatus by two series of blades, the action of which is apparent in the illustration. These blades are so shaped and set that they are in light shaving engagement with the two surfaces of the sheet. They are of metal, about 1/16-inch thick, have smooth, sharp edges, are inclined at a slight angle to the paper, and each series is arranged in a slightly curved formation so that the paper naturally draws across them.

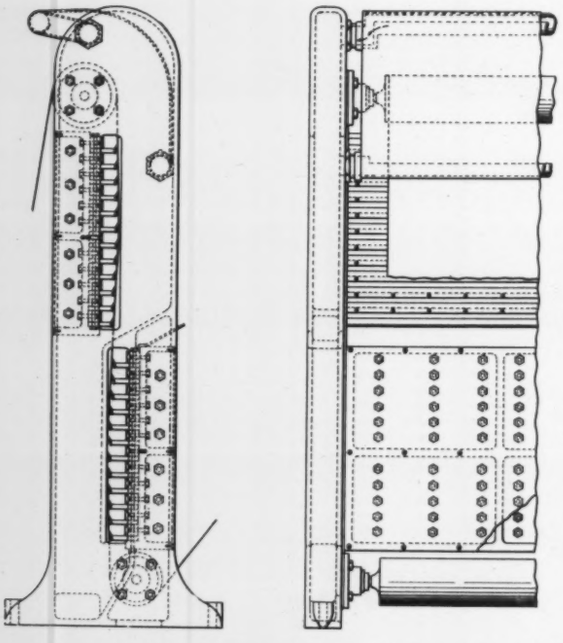


*Fig.* 1—*Water is removed from surfaces of waxed paper by action of two series of blades*

As the paper passes through at a rather high rate of speed, the liquid globules readily leave the waxed paper and cling to the blades, from which the liquid drains by gravity along troughs behind the blades into chambers in the side frames, thence back to the cooling tank.

## Nut Holds Itself in Position

MEANS for adapting quick-acting spring nuts to the effective fastening together of superimposed sheet metal parts is covered by Patent No. 2,101,287 which has been granted to George A. Tinnerman of Cleveland. This development, and two typical examples of its application, are depicted in *Fig.* 2.

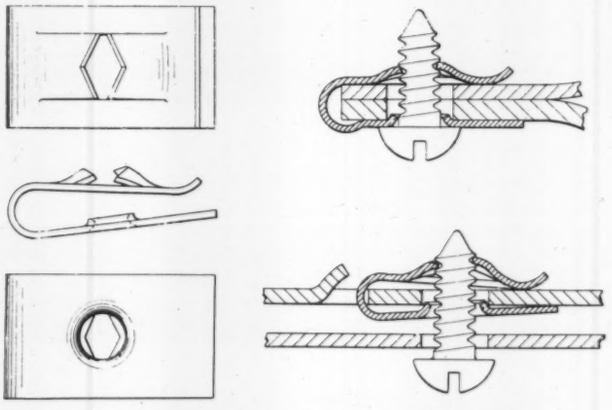


*Fig.* 2—*Spring nut is designed to be self-centering and self-holding, in line with its bolt hole*

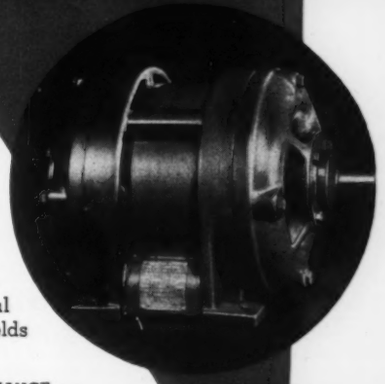
The primary object of this invention is to provide a sheet metal fastener which, when applied to a bolt hole in a blind location, will not only center itself automatically with respect to the bolt hole but also will automatically lock itself in position. This enables the assembler to insert the bolt without having to hold the fastener during the process.

The particular system of mechanical fastenings to which this present invention applies is that which was described to some length on Pages 47 and 48 of the December, 1937, issue of MACHINE DESIGN.

*The Allis-Chalmers Mfg. Co. builds standard motors of every type from 1 hp. up . . . also motors for special application.*

# UNASSAILABLE!

Allis-Chalmers Seal-Clad Motors are the sturdiest motors on the market—bar none. And in addition to their great strength, they can be depended upon, always, because they are unassailed by the weakening and destructive agents that affect other motors. Allis-Chalmers Seal-Clad Motors are unassailed . . . by metallic dust, grit, oil, moisture, chemicals, or by other destructive agents that are present, to some extent, in every plant.



The wound stator of an Allis-Chalmers Seal-Clad Motor receives an impregnating treatment similar to the conventional type of winding. But, in addition, ultimate protection is assured by a Moulded Bakelite Shield, of high dielectric and mechanical strength, which is fitted into a machined slot in the stator frame and sealed into position with a special compound. Thus the coils are completely protected by hard, smooth shields that are impervious to the attacks of damaging agents.

ISN'T THIS UNASSAILABLE ASSURANCE WORTH WHILE . . . PERFECT PERFORMANCE UNDER ALL CONDITIONS, AT NO EXTRA COST?

*For further details, write for Bulletin No. 2182*

838

MOTOR DIVISION

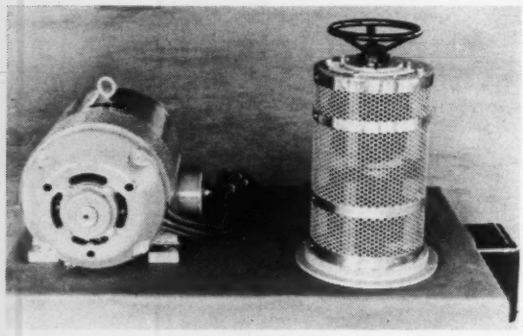
ALLIS-CHALMERS

MILWAUKEE WISCONSIN

# NEW Materials and Parts

## A.C. Motor Is Multiple Speed

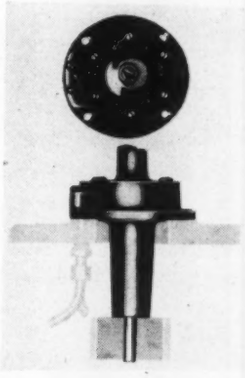
SOLUTION to the alternating current, adjustable speed motor problem is offered in a new three-phase, alternating current, polyspeed motor of Crocker-Wheeler Electric Mfg. Co., Ampere, N. J., capable of efficient and stable speed regulation over a wide range of speed. Outstanding advantages of this motor are: Fully continuous speed regulation without rheostat losses, shunt motor characteristics with speed practically independent of the load, constant torque throughout speed range, across-the-line starting and remote control. The speed regulator consists of two single-phase, induction type voltage regulators placed in one frame, with the two rotors mounted on a common shaft. With this design it is possible to obtain any speed between slightly above standstill to 1800 RPM. Uses of this type of motor include the driving of spinning frames and various textile machines, printing presses, machine tools and similar equipment where a stable but variable speed is required.



*Speed in three-phase, polyspeed motor may be varied from almost standstill to* 1800 *RPM.*

## Lubricating Pump Offered

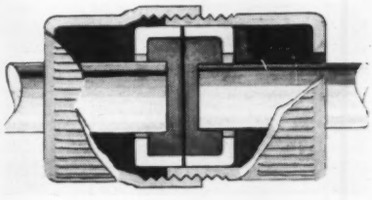
LUBRICATING pump for bearings, gears, multiple spindle drill heads and similar units, known as the ASE model, is announced by The Pioneer Engineering & Mfg. Co., 31 Melbourne avenue, Detroit. This unit is a conveniently small, compact, positive displacement rotary pump which may be mounted on practically any flat surface of the machine assembly. All moving parts are made of hardened steel and are accurately ground to close tolerances. No gland is needed because the driving gear is inside the machine. This Rollway pump is a high vacuum unit which delivers liquid immediately after rotation is started. Stopping or reversing the machine has no effect whatever on pump operation. One of its outstanding characteristics is its ability to hold its prime indefinitely.



*Gland is not needed in lubricating pump as driving gear is inside machine housing*

## Coupling Has Rubber Bushings

POSITIVE freedom from vibration and whipping are advantages claimed for Torflex, a new low cost flexible coupling, brought out by Gordon Engineering Co., 3576 Gratiot avenue, Detroit. Power is transmitted from the driving to the driven shaft through rubber bushings which are bound by pressure to the shafts by means of an arrangement, employing only six parts. The coupling provides full transmission of power even when the shafts are greatly misaligned in any plane.



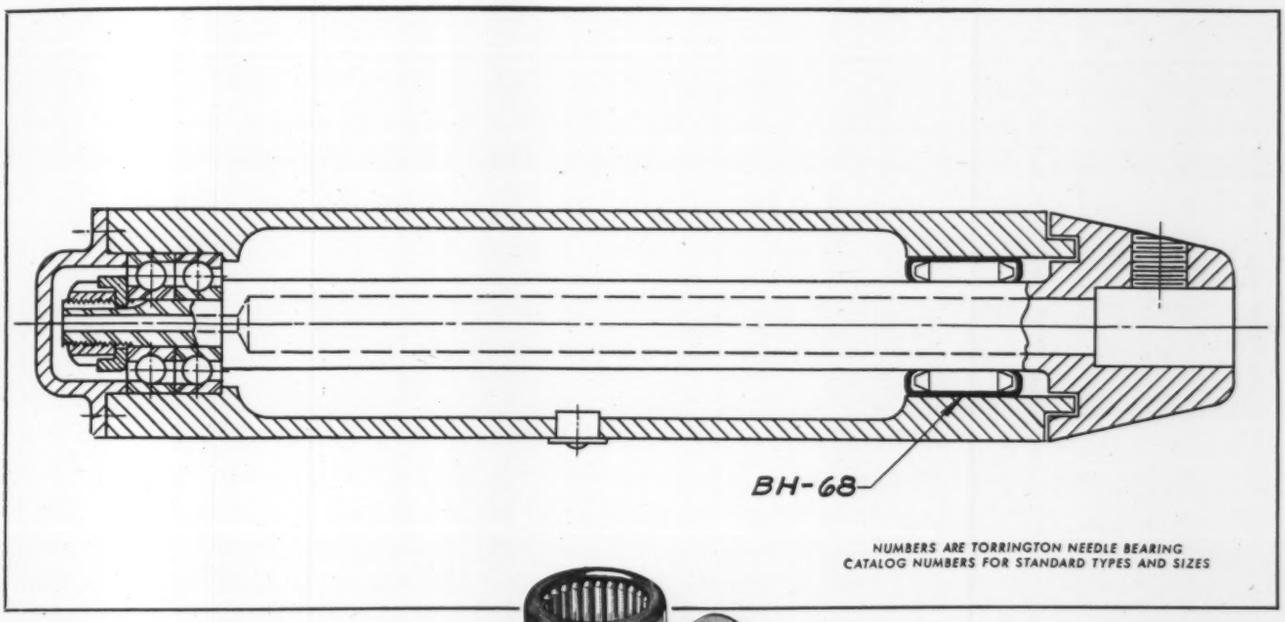
*Power is transmitted through rubber bushings which permit considerable shaft misalignment*

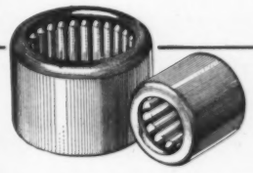
## Belt-Tightening Motor

SPECIAL belt tightening motor for overdrives, where the belt must pull on top side of pulley, has been placed on market by The Ohio Electric Mfg. Co.,

# TORRINGTON NEEDLE BEARING

## DESIGN AND SERVICE FEATURES



## SMALL SIZE PLUS CAPACITY AT HIGH SPEEDS

### Simplifies Housing Designs

Small size of the new Torrington Needle Bearing makes it ideally suitable for such applications as the one illustrated here, in which load capacity at high speeds must be combined with simple, light housing design.

In spinning tool applications the loads vary widely and speeds are usually high. The shape of the Needle Bearing—long axially and small radially—permits the use of a compact, simple housing, reducing the size, weight and cost of the tool.

The bearing's full complement of small diameter rollers gives many linear inches of contact, providing ample capacity for the high speed radial loads encountered in spinning service.

Accurately dimensioned, the Needle Bearing guides the work end of the shaft, and the turned-in lips of the Needle Bearing shell fitting closely about the shaft aid in the exclusion of dust and dirt. Highly resistant to wear, the bearing retains its original tolerances indefinitely and aids in maintaining accurate shaft alignment.

In the design shown, the radial load is carried by the Torrington Needle Bearing, and positioning of the spindle is cared for by a pair of matched open-type Torrington Ball Bearings—a typical illustration of the possibility of combining needle and ball bearings in a single application.

The long experience of the Torrington Engineering Department is at the service of manufacturers desiring assistance in the specialized problems of bearing design and layout. Further information is given in the Torrington Needle Bearing Catalog, available on request. Write for Catalog No. 9. Specifications on Torrington Ball Bearings may be obtained by requesting Catalog No. 401.

*The Torrington Company*
ESTABLISHED 1866
*Torrington, Conn., U.S.A.*
*Makers of Ball and Needle Bearings*
Branch Offices in all Principal Cities

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**FEATURES OF THE TORRINGTON NEEDLE BEARING**

| | |
|---|---|
| Small Size | Ease of Installation |
| Efficient Lubrication | Low Cost |
| High Radial Load Capacity | |

**TORRINGTON**
**NEEDLE BEARING**

Greater Design Flexibility...
Maximum Belt Drive Economy

WORTHINGTON
MULTI-V-DRIVE
with
GOODYEAR
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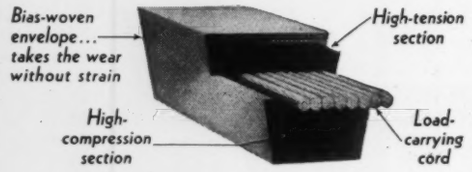


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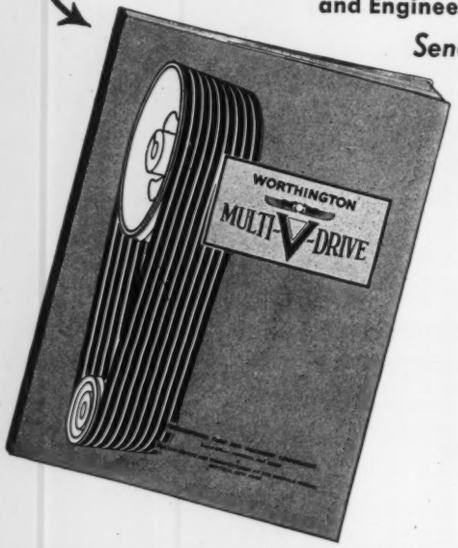


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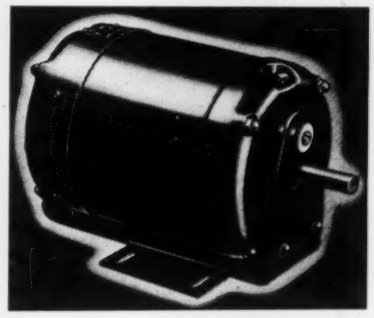
MV8-1B


5917 Maurice avenue, Cleveland. Tightener will take up an inch slack in belt and saves constant attention to belt tension. Motor is supported above and off shaft center so its own weight provides the initial belt

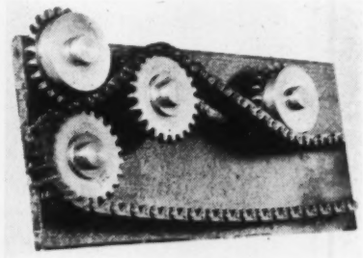


*Belt tightening device on motor will take up over an inch slack, saving constant maintenance*

tightening effect. This is increased proportionately to the load by the reaction of the rotor to the stator causing the motor to swing away from its load and tighten the belt the proper amount. Motors incorporate capacitors and thermal overload cutout switches. Entire line is redesigned in streamline style.

## Chain Has Teeth on Each Side

BACK type or "duplex" silent chain, so constructed that the links of each half of the chain are pointing in opposite directions to drive sprockets from each side has been developed by Ramsey Chain Co. Inc., Albany, N. Y. Narrow-toothed sprockets are used, engaging but one-half of the chain, with their extend-

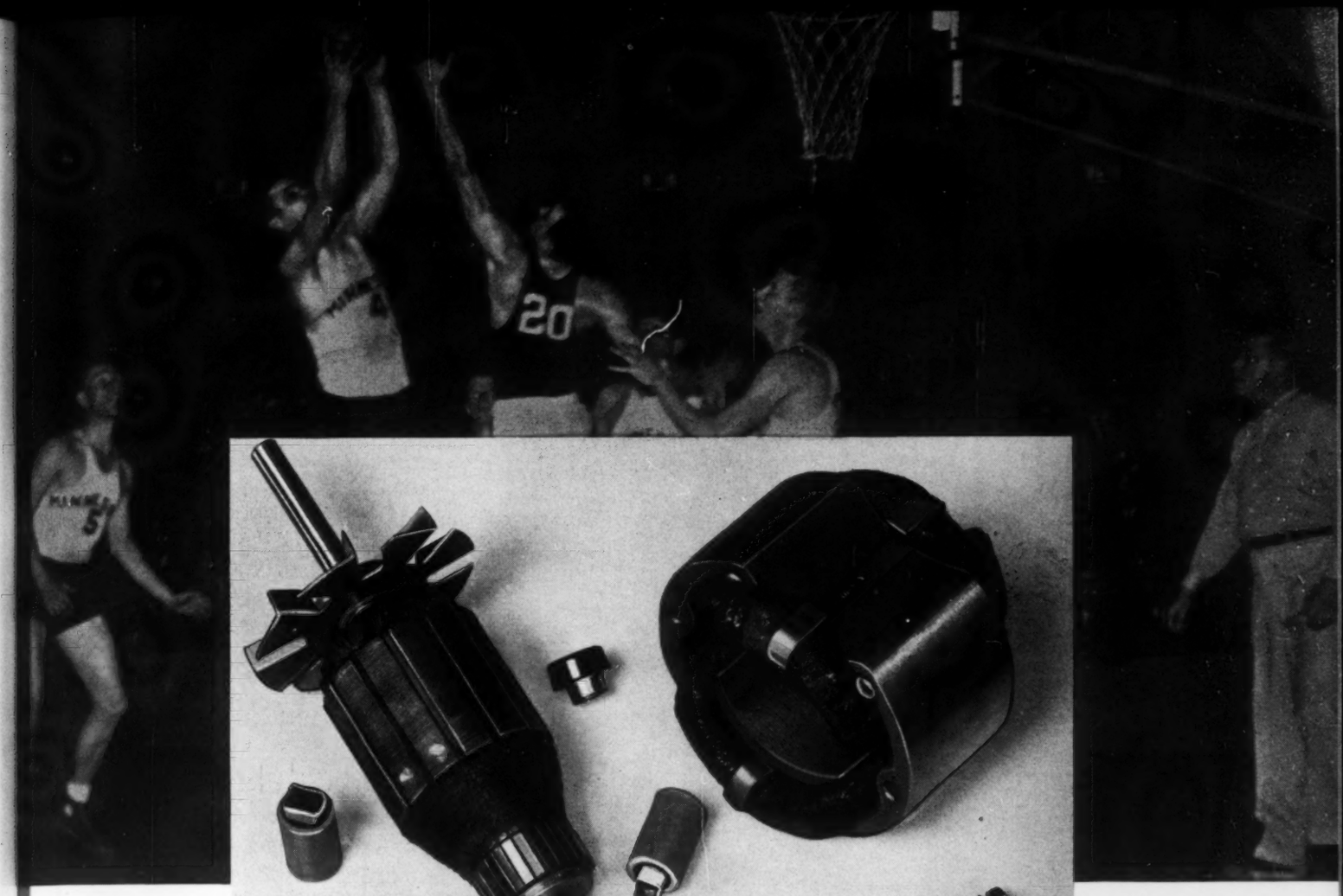


*Silent chain is designed for driving rolls placed close together in the same direction*

ed hubs supporting the other half of the chain (i. e., the backs of the links) not in engagement. It is designed particularly for operation of rolls where the sprockets must be placed close together and run in opposite directions. Any number of sprockets, spaced where desired, can be driven from either side of this silent chain with high speed and efficiency.

## Thermal Safety Device

THERMAL tripping element for motor-starting application has been developed by the General Electric Co., Schenectady, N. Y., for use with type AE-1 industrial air circuit breakers. The new unit consists of a magnetically operated tripping mechan-



*A tense moment in a tight game between the cage teams of Minnesota and Northwestern Universities.*
*(Acme Photo)*

# Like an Overtime Basketball Game

## DUMORE MOTOR PARTS GIVE PLUS PERFORMANCE

Manufacturers who must have maximum efficiency from the universal motors built into their products . . . such as business machines, medical devices, household appliances, portable electric tools and the like . . . depend on Dumore matched motor parts.* They have found in Dumore parts the same *extra power hours* for which Dumore motors are distinguished.

Dumore armatures (complete with commutators and ventilating fans), field cores and coils, brushes, brush holders, springs and plugs, furnished in sets, are manufactured with the same precision . . . undergo the same exhaustive tests and inspections . . . as do those going into complete motors bearing the Dumore nameplate.

Start now to get *more power hours* for your money. Dumore engineers welcome the opportunity to give individual attention to your particular problems. Backed by 25 years of motor-building experience they are skilled in adapting power units to all manner of special applications. Write today for latest Dumore catalog and engineering service information blank.

**Illustrated are Type K motor parts, 1/6 h. p. at 5,000 r. p. m. continuous duty, 115 volts, 0-60 cycles.*

**THE DUMORE COMPANY - Dept. 128-C - RACINE, WIS.**

# DUMORE MOTORS

## FOR Extra Power Hours

QUIET

P&H HIGH EFFICIENCY ELECTRIC MOTORS

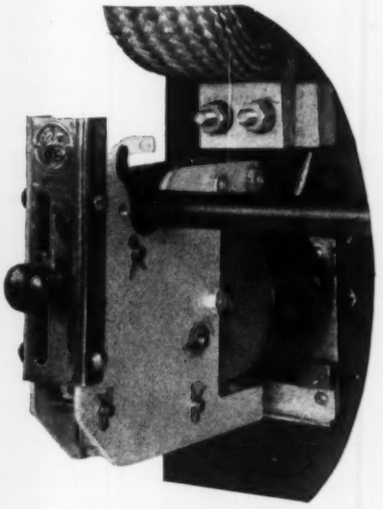
The hushed operation of these P&H High Efficiency Electric Motors is the result of their precision manufacture and perfect balance. In such fields as ventilating and air conditioning, where quietness is important, their superiority is recognized by all who know them. The fact that P&H High Efficiency Motors are now being specified in an increasing number of installations for this purpose, suggests your investigation of them. The Harnischfeger Corporation, 4556 W. National Ave., Milwaukee, Wis.

*Convertible Slip Ring and Squirrel Cage Motors up to 125 h.p. capacities. Literature sent on request.*

HARNISCHFEGER CORPORATION

MOTORS • HOISTS • WELDING ELECTRODES P&H ARC WELDERS • EXCAVATORS • ELECTRIC CRANES

ism which is restrained from tripping on overcurrent by means of a bimetallic element having thermal characteristics suitable for the starting and running protection of alternating current motors. This bimetallic unit, heated inductively from the magnetic

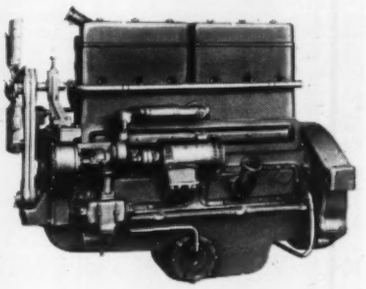


*Tripping mechanism is restrained from tripping on overcurrent by bimetallic element with suitable thermal characteristics*

circuit of the overcurrent tripping device, releases the armature of the device when the power tripping temperature is reached. On overcurrents exceeding 10 times normal the pull of the magnetic element acts independently of the thermal restraint, and instantaneous tripping occurs.

## Gas Engine Models Announced

TWO new models of gasoline engines have been announced by The Buda Company, Harvey, Ill. Known as models M-707 and M-766, they are of 707 and 766 cubic inch displacement, respectively. Both are six cylinder with overhead valves. Crankshafts are 3½ inches in diameter and connecting rods 12½ inches center to center. Bearings are the replaceable,

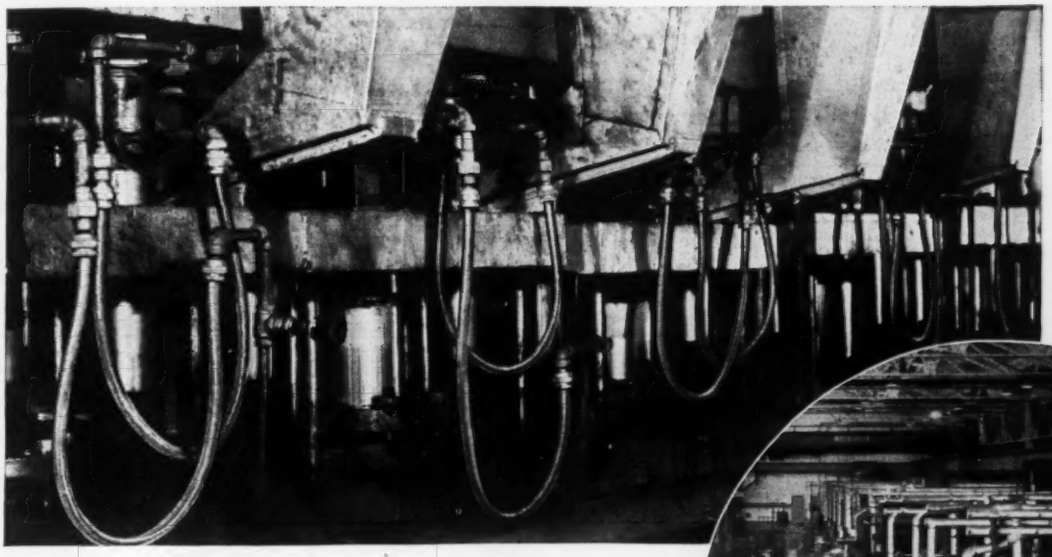


*Force-feed lubrication, replaceable insert bearings and overhead valve construction are features of engine*

precision type. Lubrication is by positive force feed pressure to all crankshaft, camshaft, connecting rod and piston pin bearings and to rocker arm shafts and timing gears. The M-707 and M-766 engines are built for various installations including shovels, cranes,

## GENERAL ELECTRIC'S MODERN MOLDING PLANT USES

# *Modern Flexible Connectors*



**LEFT**—*American Seamless installed on G. E.'s special high speed molding presses.*

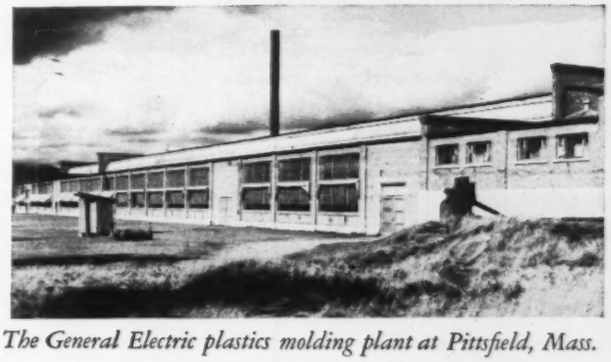
**BELOW**—*Battery of molding presses at G. E.—Pittsfield; all equipped with American Seamless.*

OVER 1,000 assemblies of American Seamless Flexible Bronze Tubing and couplings are at work in General Electric's plastics molding plant at Pittsfield, Mass.

The General Electric system of heating the molds calls for flexible tubing to convey water at 370° F. under 200 pounds pressure—and the pressure must be maintained with an even, smooth flow at all times. It is a tribute to our quality that General Electric chose American Seamless for this important duty. Regardless of whether hot water is the heating medium, or whether steam, or steam and cold water alternately must be conveyed to the molds or platens, American Seamless Flexible Metal Tubing has no rival—it is as leakproof as the *seamless tubes* from which it is made.

Available in several metals, principal of which is bronze, American Seamless is easy to install and simplifies quick changes from one mold to another.

Let us send you our 20-page catalog which describes, illustrates, shows typical installations and presents valuable engineering data on this modern, *leakproof* flexible metal tubing. Ask for Bulletin SS-3. 37622



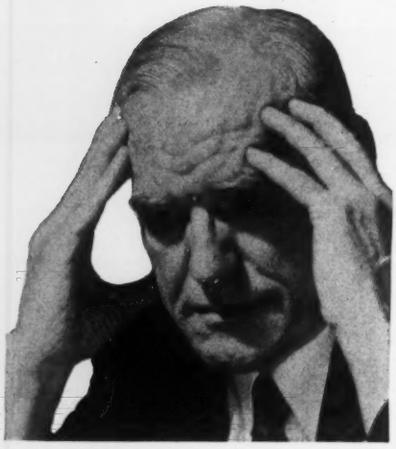
*The General Electric plastics molding plant at Pittsfield, Mass.*

**THE AMERICAN BRASS COMPANY**

# *American Metal Hose Branch*

**General Offices: WATERBURY, CONNECTICUT**

"I CAN'T STAND



Grit in a pencil!"

No Grit
No Scratch
No Smudge

GRITTY graphite grates! Gr-r-r—the sound drives draftsmen wild. No wonder more and more pencil craftsmen switch to "Castell"—the drawing pencil with the chemically-prepared soft, natural graphite which possesses a purity between 99.5% and 99.8%. Our patented "microlette" process produces a fine graphite particle and a remarkable deepness of tone for which "Castell" is famous. Switch to "Castell"—it helps you do better work and is easier on the nerves. 18 unvarying degrees.

Castell
DRAWING PENCILS . . . 15c
Made in Bavaria

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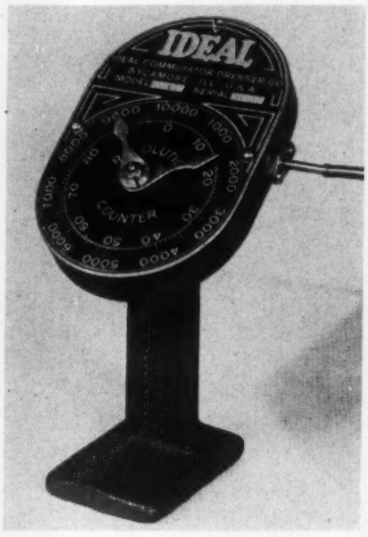
heavy duty trucks, stationary and portable compressors, locomotives, railcars, etc.

## Counter Is Accurate at Speed

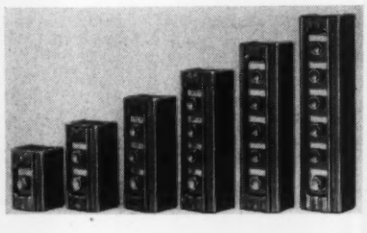
RECENTLY acquired by the Ideal Commutator Dresser Co., 1059 Park avenue, Sycamore, Ill., the Belden revolution counter has been improved. Outstanding feature is its accurate operation at high speed, a condition that causes many counters to slip a cog and register inaccurately. It is driven by a flexible shaft and can be mounted either near or some distance away from a machine. The complete assembly consists of a cast-iron base, a dust-tight stamped metal case and dial, and a flexible coupling for connection to the driving shaft. Two pointers are incorporated in the counter, one reading from 0 to 100 revolutions and also from 0 to 10,000; the other indicates the number of hundreds of revolutions counted. The pointers are quickly reset to zero by turning the dial by hand.




*Flexible shaft drives revolution counter which operates with extreme accuracy at high speeds*

## New Line of Pushbutton Switches

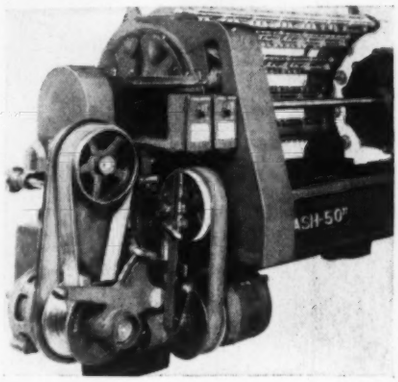
HEAVY duty pushbutton switches for alternating and direct current control circuits have been placed on the market by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. There are eight different units, including lamp receptacle and rotary selector switches, which may be grouped together in combina-



*Pushbutton switches are easily built into machines or may be mounted on a panel*

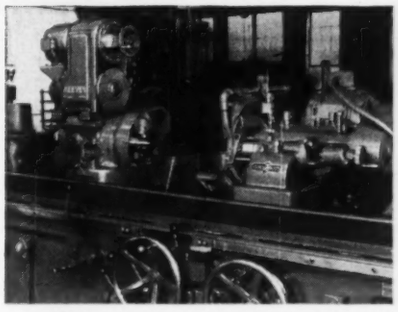
# What's New
## IN VARIABLE SPEED CONTROL

## SANDING



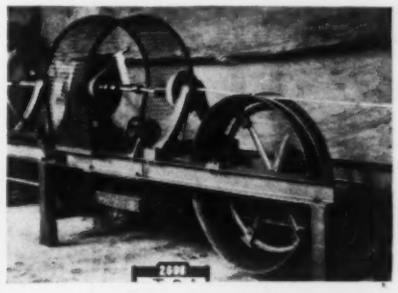
How REEVES Speed Control permits handling more shapes and sizes of product on the same machine is illustrated by this automatic sander. This machine is used in woodworking plants to sand turned wooden pieces of irregular shapes, ranging from ⅜″ to 6″ in diameter and from 2″ to 72″ in length. The sander is standardly equipped with two REEVES Vari-Speed Motor Pulleys. One controls the speed of rotation of the work piece according to its size, varying speed from 1,000 to 3,000 r.p.m. The other controls the speed of the revolving heads on which the work is mounted, thus controlling sanding time as these heads pass the work from brush to brush. Production rate may be varied from 10 to 30 pieces a minute according to type of turning and variety of wood, providing the best results in sanding.

## GRINDING

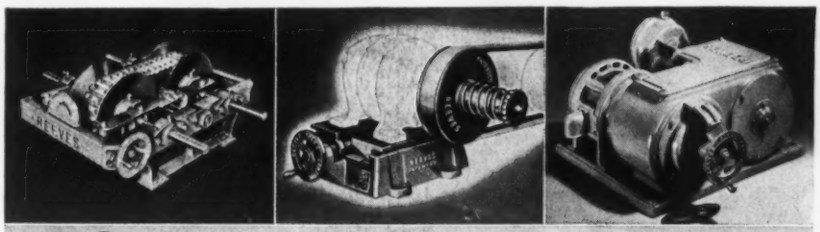


A vertical design REEVES Motodrive replaced rheostat control on this new grinder at a substantial saving. All vibration is eliminated through mounting the Motodrive on live rubber. This compact, self-contained variable speed power plant provides infinite speed selectivity of headstock speeds as required by differences in diameter of shafting which this grinder handles.

## TAPING



This is a two-head taping machine manufactured by the New England Butt Co. It is used to apply paper or friction tape to cable. Since smaller sizes of cable can be wrapped faster than larger sizes, variable speeds are essential for greater efficiency. This is accomplished through regulation by a REEVES Variable Speed Transmission, which provides any desired operating speed and enables this machine to handle cable of different kinds and sizes up to 1½ inches in diameter. Operator selects proper speeds as needed merely by turning handwheel control.



**THE 3 BASIC UNITS IN THE COMPLETE REEVES LINE**

**VARIABLE SPEED TRANSMISSION.** Provides infinite speed adjustability over wide range. Accurate and positive at all speeds. Modern, compact open and enclosed designs, vertical and horizontal. Fifteen sizes—fractional to 100 h. p. Speed variations from 2:1 to 16:1 inclusive.

**VARI-SPEED MOTOR PULLEY.** Simplified development of Transmission. Mounts on standard shaft of any constant speed motor. Forms direct drive to machine. Sliding motor base is moved forward or back for speed changes. Seven sizes—fractional to 7½ h. p., 3:1 range of variation.

**VARI-SPEED MOTODRIVE,** Combines in one compact, self-contained enclosure, constant speed motor, REEVES speed varying mechanism and reduction gears (where required). Available in space-saving horizontal and vertical types—¼ to 10 h. p. Speed variations 2:1 to 6:1 inclusive.

★ MODERN
★ ACCURATE
★ TIME-TESTED

# REEVES SPEED CONTROL

### REEVES ADVANTAGES

***Positive transmission*** **of power at any speed and under varying loads; no slippage or fluctuation.**

***High efficiency*** **. . . negligible loss of power transmitted.**

***Simplicity of design*** **and operating principle . . . few moving and wearing parts; long life and trouble-free service.**

***Wide range*** **of designs, sizes, speed ratios, controls . . . insuring the correct application for your individual needs.**

***A nation-wide*** **engineering organization . . . at your service, without obligation.**

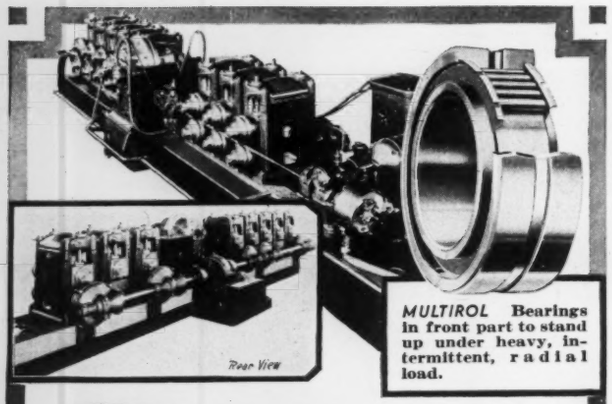
**REEVES PULLEY CO., Dept. H, Columbus, Ind.**

Please send information on your complete line of speed control equipment and how it is being used by machinery builders.

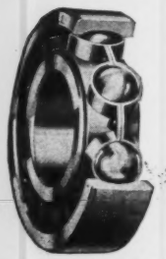
NAME.....

COMPANY.....

ADDRESS.....




*MULTIROL* Bearings in front part to stand up under heavy, intermittent, radial load.



McGILL Radial Ball Bearings, single row type, used in back part of tube mill to withstand end thrust.

## McGILL Bearings Ideal for the Job

American Electric Fusion Corporation, Chicago, manufactures "A. E. F." tube mills that form, weld and straighten 1½" to 2½" tubing from 16 to 24 gauge flat stock in one operation. There's a job for bearings! McGILL Bearings are doing it, too.

The McGILL *MULTIROL* Bearings have greatly increased bearing surfaces in proportion to their overall size, enabling them to far outrun plain and ordinary anti-friction types in this work, and totally eliminate bearing troubles and replacements.

One reason why McGILL Ball Bearings were chosen is because of their **bronze retainers.** Bronze offers least resistance to steel, dissipates heat, runs quietly and cool, prevents crystallization. Only McGILL Ball Bearings have **bronze retainers.**

## For Every Need

McGILL *MULTIROL* Precision Needle Bearings are stocked in standard sizes from ⅝" to 6" bore, single and double rows of rollers at low, volume production prices. Corrosion, heat-resisting and other designs gladly engineered to specific requirements.

McGILL Precision Ball Bearings are made in standard sizes; single and double row radial, duplex, angular contact and grease plate types. Special bearings can be made to meet your needs. Write for catalog.

**McGILL MANUFACTURING CO.**

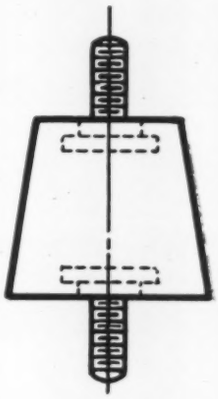
**Bearing Division, 1450 N. Lafayette St.**

**VALPARAISO, IND.**


tions to meet practically all requirements. The units are suitable for built-in control or for panel mounting. Pushbutton stations of one to seven units are available in attractive heavy drawn steel cases with black enamel finish and etched chromium-plated legend plates. Cover is recessed so that the pushbutton is effectively shrouded against accidental operation but there is no interference to operation with a gloved finger.

### Adds to Line of Rubber Insulators

ADDITION to the Vibro-Insulator line of rubber to metal type machine mountings has been announced by The B. F. Goodrich Co., Akron, O. Known as the type 30 Vibro-Insulator, it is made of a rubber compound having an exceptionally low permanent

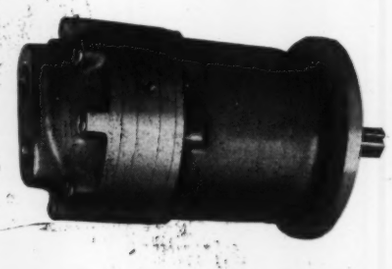


*Bolts are bonded into rubber allowing insulators to carry loads in shear*

set. Rubber and metal are bonded together and each insulator is provided with bolts for attaching to equipment. It is designed to carry loads in either shear or compression, having a limit of 30 pounds in shear and 120 pounds in compression. This type of insulator is particularly useful in compression as a mounting for air compressors and refrigeration units.

### Fluid Motor for Feed Applications

TWO-SPEED, oil power fluid motor of the multiple piston type, designed especially for machine tool feed applications, has been placed on the market by



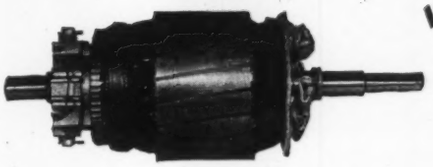
*Two torque ratings of fluid motor enable it to meet wide range of feed requirements*

Sundstrand Machine Tool Co., Rockford, Ill. A feed range from 3 to 120 RPM and a rapid traverse rate

# CHECK ✓ THESE FEATURES OF Wagner Motors

## They are Essential for Service

### Rotor

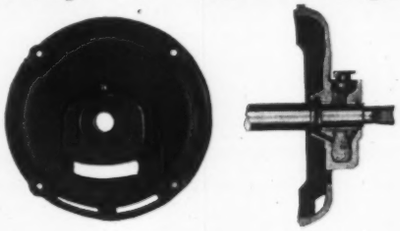


All Wagner rotors are dynamically balanced to insure freedom from vibration. Rotor slots are skewed and combined with careful electrical design to insure a motor with a minimum of magnetic noise. Rotor shaft is designed to carry mechanical overloads without perceptible deflection.

### Stator

Wagner stators are known for their strength and rigidity, in addition to their mechanical simplicity. Stator coils are well insulated and securely wedged in place. Stator core and windings are thoroly impregnated with heavy insulating varnish and carefully baked in drying ovens to drive out all moisture. Frame is of rolled steel—strong, rigid, will not get out of alignment.

### Endplates and Bearings

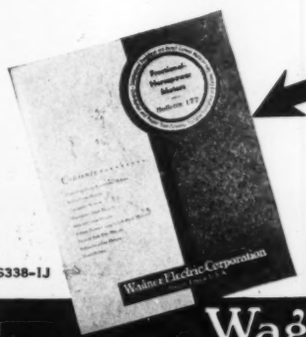


Concentrically machined endplates and diamond-bored bearings—insure true alignment of bearings, perfect centering of shaft, and uniform airgap. Oil wells are roomy—hold large quantity of oil-soaked wool yarn which carries an uninterrupted supply of filtered oil to all bearing surfaces.

### Base Construction

Wagner fractional-horsepower motors can be equipped with either rigid-mounted base, resilient-mounted base, or flanged or machined endplate mounting. Bases are formed from steel plate and are of electric-welded construction. Mounting slots are so spaced as to permit interchangeability of motors of the same frame size.

*There are many other details about Wagner fractional-horsepower motors that should be of interest to engineers and manufacturers of motor-driven machinery and appliances. Wagner welcomes an opportunity to demonstrate their features of superiority that will prove useful to you.*




**Ask!**

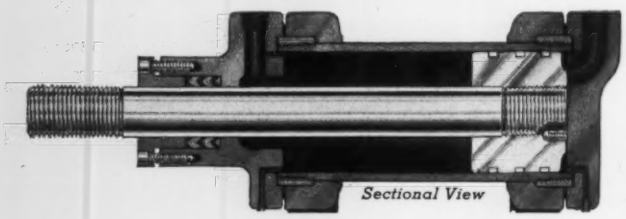
For This Bulletin No. 177
on
Wagner Fractional-Horsepower Motors
IT'S FREE! No obligations involved

MS338-IJ

Wagner Electric Corporation
6400 Plymouth Avenue, Saint Louis, U.S.A.

FANS . . . MOTORS . . . TRANSFORMERS . . . BRAKES

# STRONGER and SIMPLER



*Sectional View*

● This new type patented Hannifin high pressure hydraulic cylinder provides a strong, simple construction that is easy of application, presents a better appearance, and is adaptable to a wide variety of uses. High efficiency hydraulic power and ability to withstand severe service are assured.

**NO TIE RODS.** This simplified design is stronger and eliminates a source of leakage. End caps may be removed without collapse of other parts of the assembly.

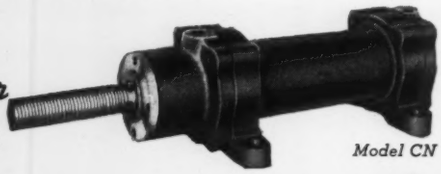
**UNIVERSAL CAPS.** Either end cap may be positioned, independently, so that inlet port is at top, bottom or either side. Either cap may be moved without disturbing the cylinder mounting or any other parts.

**AIR VENT PLUGS.** Each end cap has air vents on three sides. With the inlet port at either side or bottom there is always an air vent plug at the top.

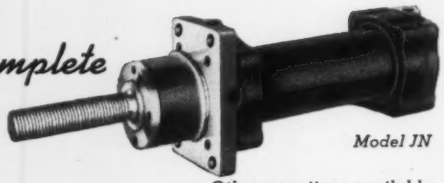
**LEAK-PROOF.** Special mirror finish honing produces a cylinder bore straight, round, perfectly smooth, and concentric with the end caps. A perfect piston seal is obtained.

**MANY TYPES AND SIZES.** Hannifin Hydraulic Cylinders are offered in six mounting types, with small diameter piston rod, 2 to 1 differential piston rod, or double end piston rod, and a full range of sizes for working pressures up to 1000 and 1500 lbs./sq. in. Other types built to order.

*Write for Bulletin 35-MD Giving Complete Data*



*Model CN*



*Model JN*

*Other mountings available*

**HANNIFIN MANUFACTURING COMPANY**

*Engineers • Designers • Manufacturers*

*Pneumatic and Hydraulic Production Tool Equipment*

621-631 SOUTH KOLMAR AVENUE • CHICAGO, ILLINOIS

# HANNIFIN

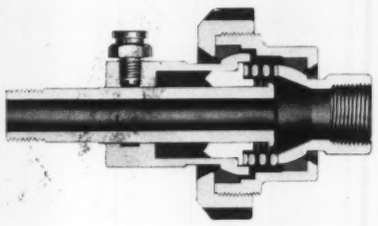
## HYDRAULIC CYLINDERS


of 2000 RPM can be obtained with this motor by driving it with the same standard Sundstrand pumps used to provide feeding movements by means of pistons and cylinders. The high ratio of speeds and two torque ratings meet the requirements of a wide range of feed applications to moving members on machine tools. The unit illustrated is the 4-MC model and has a rating of 100 inch-pounds per hundred pounds pressure for feed. It is 6½ inches in diameter and 9½ inches over all.

### Flexible Ball Joint Developed

DESIGNED to supply steam, gas or fluids from a fixed or stationary supply pipe to a rotating drum or member without leakage is the function of a flexible ball joint (type 7R-8CR) brought out by Barco Manufacturing Co., 1801 Winnemac avenue, Chicago. Rotating sleeve is the only part that revolves. This sleeve

*Rotating sleeve is designed to slide in and out to take care of end play in revolving drum*

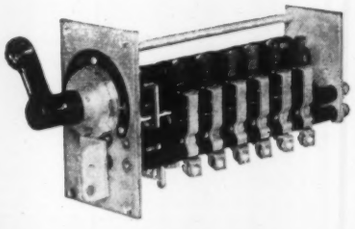


is also made to slide in and out to take care of end play in revolving drum. The double ball design provides the necessary flexibility to compensate for slight misalignment or eccentricity of movement and makes a leakproof seal.

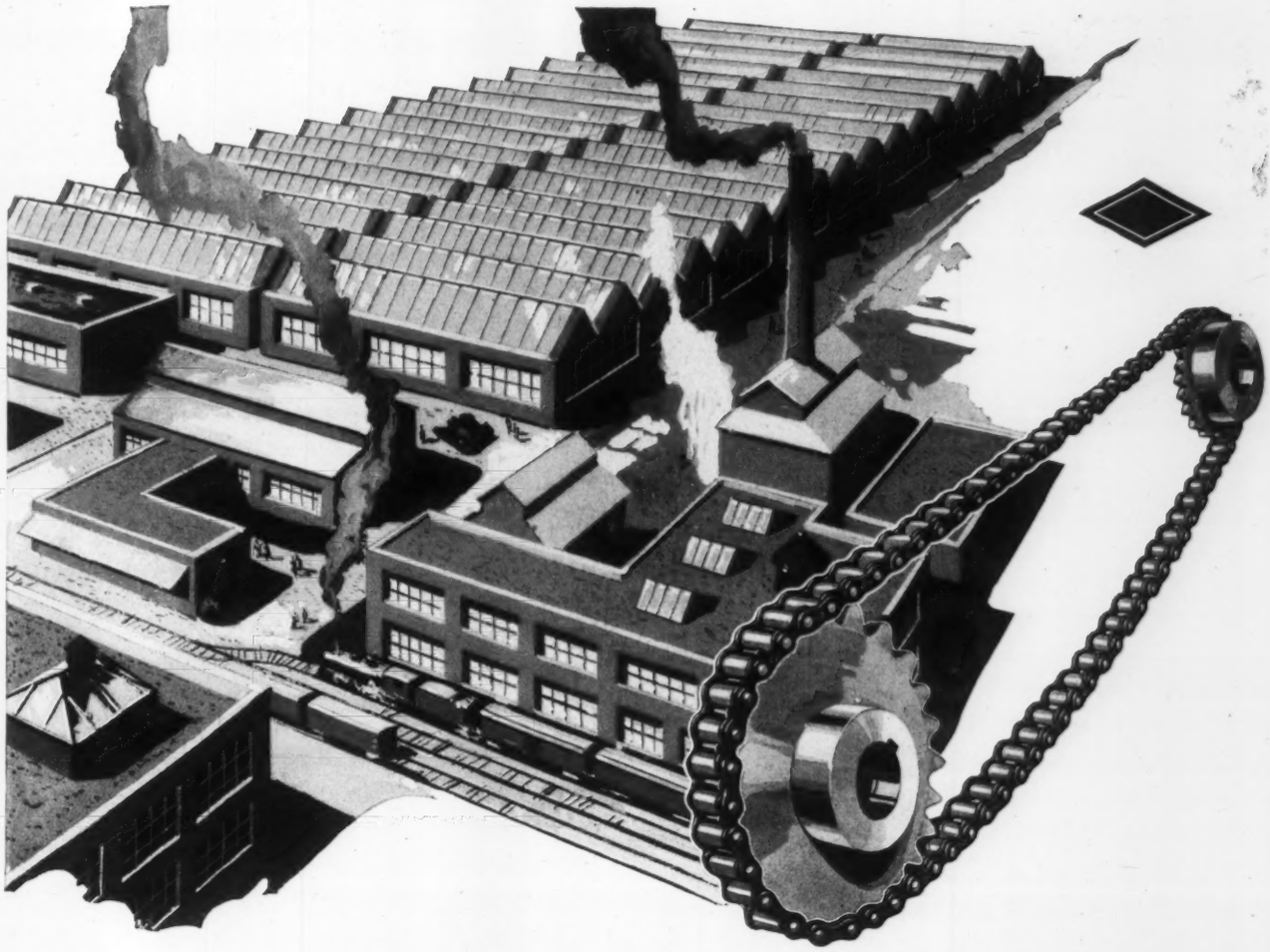
### Cam Switches for Machine Tools

DEVELOPED primarily for use in conjunction with machine tool equipment, a line of rotary cam switches for various multicircuit applications is announced by General Electric Co., Schenectady,

*Switch is available with 10 circuits and as many as 12 positions in 360 degrees of rotation*



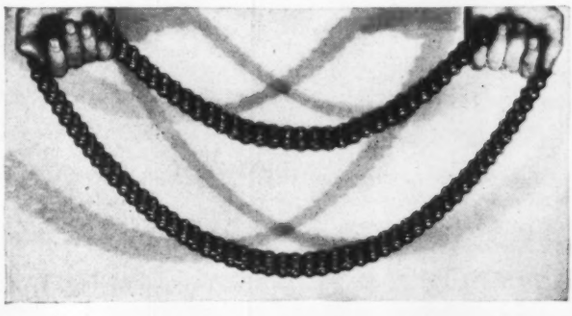
N. Y. The switch consists of a series of cam bushings mounted on a shaft supported by two end plates. Steel-backed, silver to silver contacts contribute to long life; supports for these contacts, mounted securely on the tie rods, are insulated by tubes of high dielectric strength. The switch may be obtained with



# From a Few–to 5729 Diamond Drives in the Plants of One Company

● Beginning with a few Diamond Roller Chain Drives 18 years ago—one manufacturer alone now has nearly six thousand of these drives in operation.

It is reasonable to assume that good proof of the high power transmitting efficiency,—long trouble-free life—maintained high production rates had much to do with the constant increase of the number of Diamond Drives installed.



You can obtain such proof too—a few Diamond Drives in your plant will give you actual records for comparison. You will benefit by the advantages mentioned above and through the elimination of bearing troubles and slipping,—as well as by reducing replacement and adjustment troubles.

Our latest 100-page catalog has been painstakingly prepared to make easy the selection of chains for any drive...Let us mail you a copy. DIAMOND CHAIN & MFG. CO., 435 Kentucky Ave., Indianapolis, Ind. *Offices and Distributors in Principal Cities.*

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## ROLLER CHAIN

# TOUGH GEARS *for a Tough Job*

● The Bulldozer's job is tough. Every part going into it must be tough, especially the gear pump, operating the hydraulic control of the blade.

So the Hydraulic Equipment Co., manufacturers of the Gear Pump on one of the most popular lines of Bulldozers, tested mighty carefully before selecting gears for their pump.

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For Ohio Gears met the rigid specifications, stood the gaff under test, and delivered day-after-day satisfaction for Hydraulic, accredited as one of the most efficient high volume, high pressure gear pumps.

You'll find Ohio Gears, stock and special, highly efficient for your gear requirements; Ohio skilled gear engineers ready to cooperate with you in solving tough gear problems. Write for the new catalog and get in touch with the nearest representative.

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**1333 EAST 179TH STREET • CLEVELAND, OHIO**

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*SAN FRANCISCO, CALIF. Adam-Hill Co., 244-246 Ninth Street.
INDIANAPOLIS, IND. A. R. Young, 518 North Delaware Street.
LOUISVILLE, KY. Alfred Halliday, 330 Starks Building.
DETROIT, MICH. George P. Coulter, 322 Curtiss Building.
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BUFFALO, N. Y. F. E. Allen, Inc., 2665 Main Street.
NEW YORK CITY, N. Y. Patron Millwright & Transmission Co., 154-156 Grand Street.
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NEW ENGLAND. George G. Pragst, 260 Esten Ave., Pawtucket, R. I.
PITTSBURGH, PA. Industrial Sales & Engineering Co., Box 8606, Wilkinsburg, Pa.
SALT LAKE CITY, UTAH. A. O. Gates, 619-629 South Fifth West Street.
*Stocks carried.

OHIO GEARS

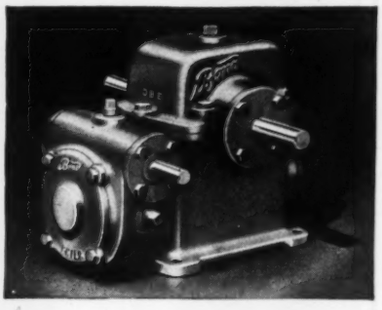
the maximum 10 circuits and with as many as 12 positions in 360 degrees of rotation. Enclosures for the unit, since it ordinarily is built into machines, have not been made available.

## Composite Type Stainless Sheet

NEW stainless steel, Ludlite, backed with a tough, flexible, nonmetallic material which enables it to be easily attached to wood, concrete and other surfaces has been announced by Ludlum Steel Co., Watervliet, N. Y. It has been especially recommended for ice box lining and general refrigeration insulation. As a light gage steel is used, Ludlite can be cut with heavy scissors, shaped or bent by hand and nailed, screwed or cemented into place with comparative ease.

## Unit Has Great Speed Reduction

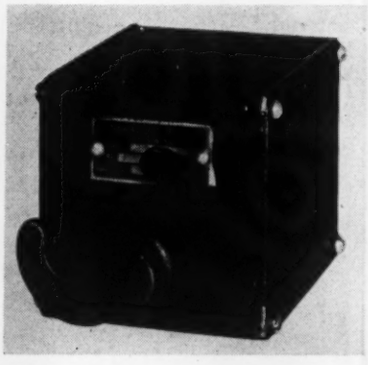
DOUBLE reduction, type B, speed reducer brought out by Charles Bond Co., 617 Arch street, Philadelphia, and described in the February issue of MACHINE DESIGN is illustrated here. Ratios as high as 4000 to 1 are available in both horizontal and vertical types.



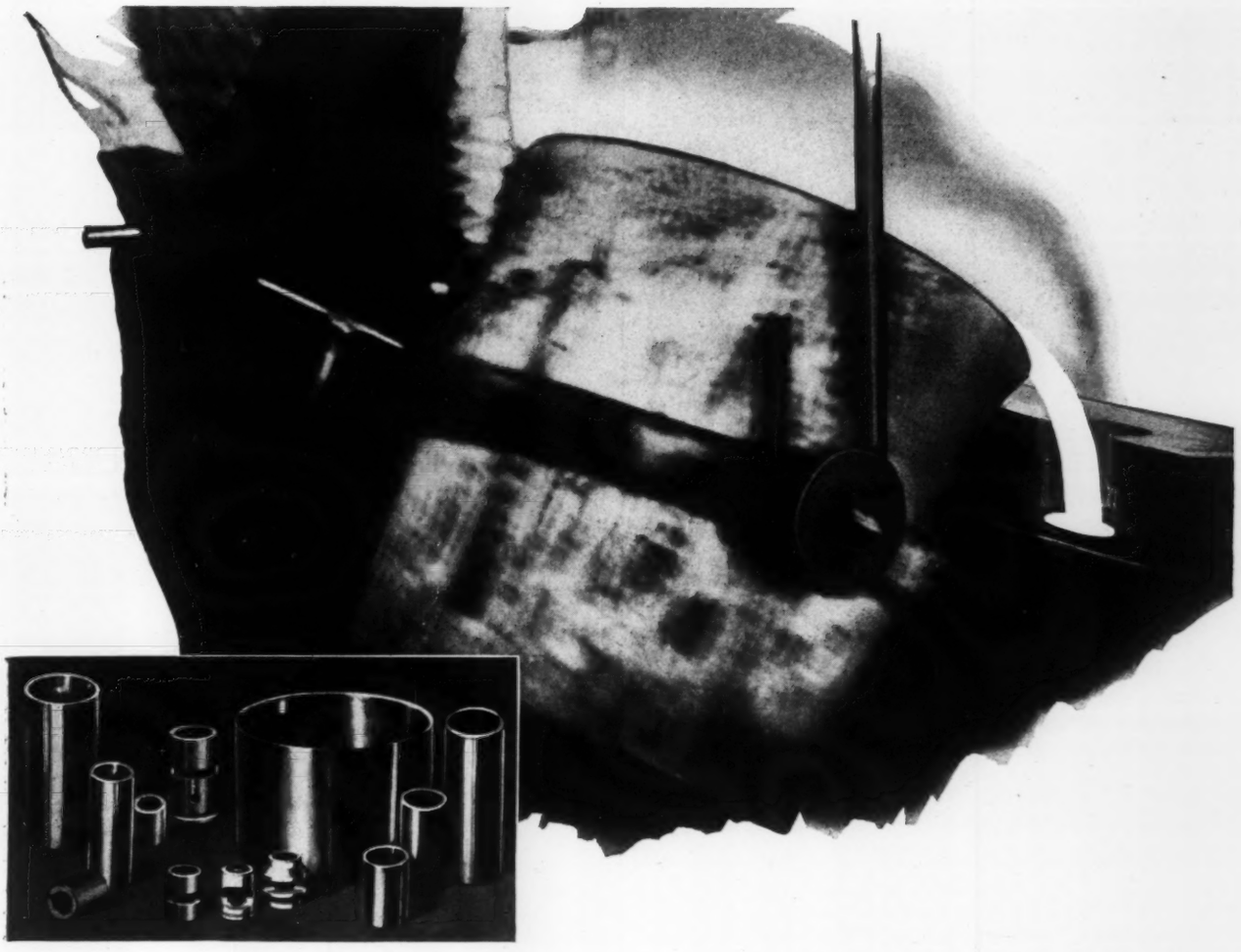
*Bronze worm gears are used with steel worms mounted in roller bearings*

## Limit Switch Is Oiltight

PARTICULARLY suitable for machine applications is the new CR9440-B1B oiltight Alnico snap-action limit switch developed by the General Electric Co., Schenectady, N. Y. Of single-pole, double-throw design, the switch has silver-faced tips on both the mov-



*Steel case with gasketed sides insures protection from oil and dirt in limit switch*



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You can buy from stock Bunting Bearings completely machined, ready for assembly, in over 600 different sizes and Finished Bunting Bearings for service replacement in all makes of electric motors from 1/40 to 60 hp. These Bunting Standardized Bearings are available instantly in any quantity at low cost, making it convenient for you to enjoy Bunting Quality with no sacrifice of time nor investment. Write for catalog.

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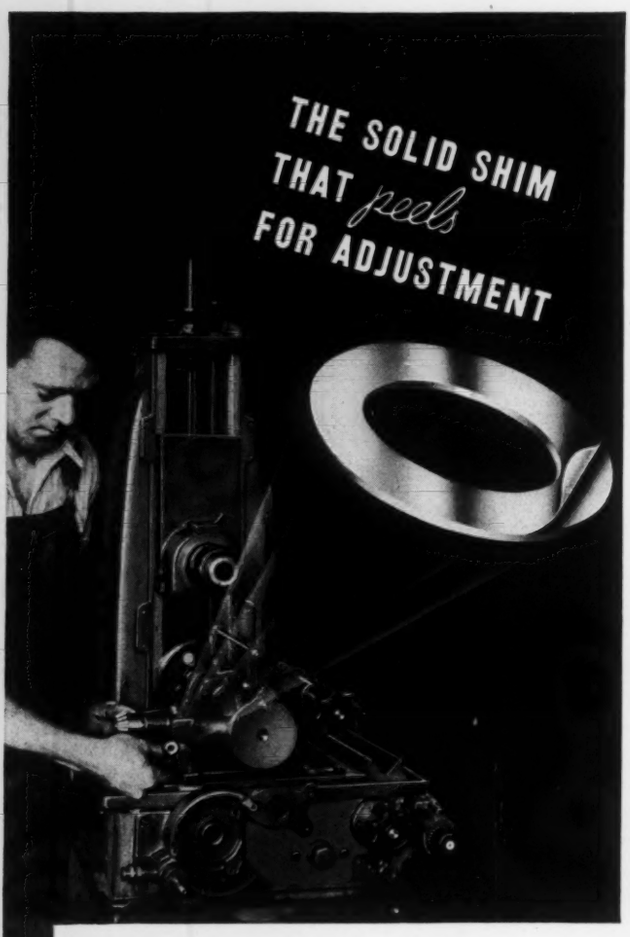


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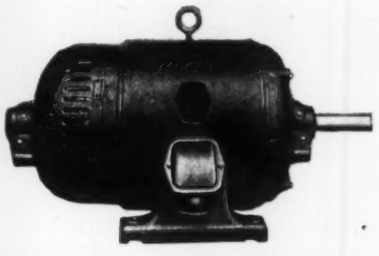
ing and stationary contacts to insure reliable operation and long life. Where a small, compact, heavy-duty reversing limit switch is required to open or close a control circuit and where maintained accuracy of operation is of primary importance, this switch is well suited. Protection from oil is insured by enclosing the switch in a steel case with two gasketed sides. With the side plates removed the terminals are easily accessible.

## Low Starting Current for Motor

TO MEET rigid starting current requirements of large motors and give a minimum of undesirable line voltage variations, a new polyphase motor (type RT) has been brought out by Wagner Electric Corp.,



*Locked torque of motor is twice full load torque and locked current little more than three times full load*

6400 Plymouth avenue, St. Louis. The motor was designed to possess the desirable features of comparatively low starting current, high starting torque, satisfactory operating characteristics and good speed regulation. The RT motor has a locked torque of about twice full load torque and a locked current of from three to three and one-half times full load current. It is available in a large variety of ratings but will ordinarily be built only in sizes of 40 horsepower and larger.

## Finish Is Resistant to Abrasion

OFFERED in two spraying and two dipping qualities, a finish known as S-W Satin-Glo for business and office machines as well as metal furniture has been developed by Sherwin-Williams Co., Cleveland. The finish is resistant to severe abrasion, chemicals and cleaning soaps, and for ordinary applications only one coat is necessary. Satin-Glo is built around a chemically evolved vehicle developed to produce the toughest known finish when baked. It is offered in olive green and other colors if quantity requirement justifies special runs. The paint finds many applications on domestic and office machinery.

## Cord Connector Is Compact

DESIGNED for use with all kinds of electrically-operated portable appliances, a small sized cord connector with "twist lock" features is announced by

# A SWITCH THAT'S TRUSTED To Help Move Mountains!

## KON-NEC-TORS Keep World's Largest Shovel On An Even Keel

One of the world's largest structures capable of overland movement on its own traveling "foundation," this 2,500,000-lb. Bucyrus-Erie stripper is kept level while moving over uneven footing by a unique electrical "sense of balance."

Four General Electric KON-NEC-TORS serve as nerve centers in the patented leveling system that controls hydraulic jacks, raising or lowering the "legs" on the tractor units by an electrically-driven pump.

Whether the job be moving mountains with a mighty shovel, or safeguarding a baby's health by a sensitive temperature regulator . . . wherever electrical circuits call for positive unfailing control . . . KON-NEC-TOR Mercury Switches are the first choice. They are wear-proof and trouble-free . . . easily adapted to the design requirements of electrical equipment, large or small.

Write today for the new catalog, "KON-NEC-TOR," which illustrates each type and gives complete specifications and valuable engineering suggestions. General Electric Vapor Lamp Company, 825 Adams Street, Hoboken, New Jersey.

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—such as these, and numerous others, are the logical product of a skilled organization with a deft 'feel' for *precise* work. . . . Note the *Combination* Worm-gear, rotating as a Gear on one side and as a Worm on the opposite side.

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Gear Specialties

INCORPORATED

CHICAGO

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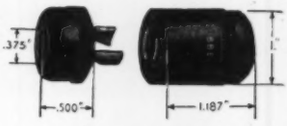
Harvey Hubbell, Inc., Bridgeport, Conn. The connector is made of brown Bakelite and is available in two ratings, 10 amperes-250 volts and 15 amperes-125




*Connector is made of brown Bakelite and is fitted with cadmium plated cord grips*

volts. Cadmium finished cord grips are available to prevent wire from pulling from connector. Small size of the connectors makes them ideal for cramped installations.

## Combination Fixed Condenser Offered

THREE types of fixed condensers, ideal for compensating reactance drift due to heating in tuned high frequency circuits have been developed by Erie Resistor Corp., 645 West 12th street, Erie, Pa. They consist of a ceramic dielectric with coated plates of pure silver fired on at high temperatures. One type of Ceramicons has a definite positive temperature coefficient and another type has a definite negative temperature coefficient. By combining them in one unit any temperature coefficient between the limits of the two individual units may be obtained.

## Engineering Department Equipment

### Speedy Developer Is Announced

FINISHED prints are almost immediately available with the "type 1000" developing machine brought out by Ozalid Corp., 354 Fourth avenue, New York. Only a few minutes are required for warming up, and two simple steps of exposure and dry development complete the process. Machine is very compact and has a developing speed of 32 linear inches per minute and will accommodate material

*Developing machine may be combined with horizontal printer to form compact unit*

# YOU PROFIT TIME AFTER TIME *BY PUSHING WELDED DESIGN*

The part shown is a platform stop for an industrial lift truck. By changing over to welded design with steel stampings, the manufacturer reduced costs from $1.50 to $1.20. Weight of the part was reduced 35%. The steel stop is practically unbreakable.

Welding gives you engineering freedom to lower costs and improve the product time after time, keeping your achievements constantly in the eyes of the management. That is why so many engineers and executives who push welding have improved their position and increased their earning power. You are *bound* to profit by pushing changeover to welding.

Write for a free copy of the new book, "How to Change Over to Welded Design for Profits." It includes the experiences of a large number of progressive manufacturers.

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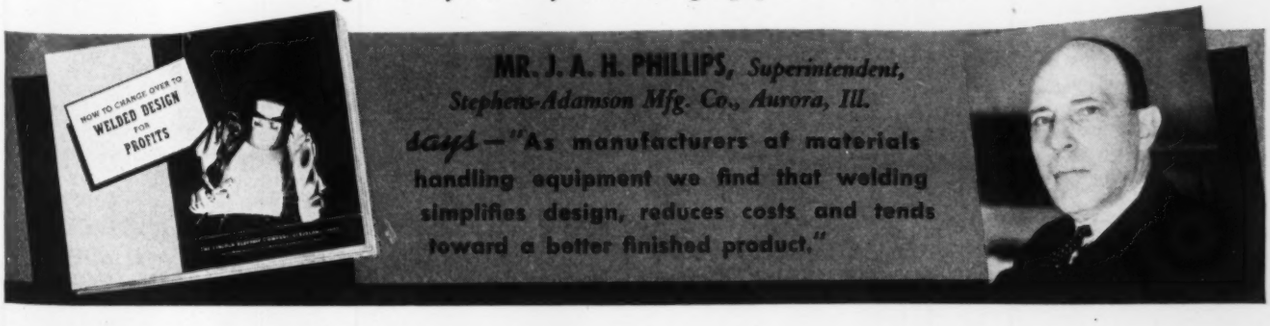
*Largest Manufacturers of Arc Welding Equipment in the World*


HOW TO CHANGE OVER TO
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PROFITS
MR. J. A. H. PHILLIPS, Superintendent, Stephens-Adamson Mfg. Co., Aurora, Ill.
says—"As manufacturers of materials handling equipment we find that welding simplifies design, reduces costs and tends toward a better finished product."

**UNUSUALLY DEPENDABLE**

**Economical and Trouble-Free Motor Power . . .**

***Designed for Easy Installation***

These are the *very* important things to consider when you select the power for your Gasoline driven machines. For, the product you make is greatly dependent—and often judged—by the performance of the power unit.

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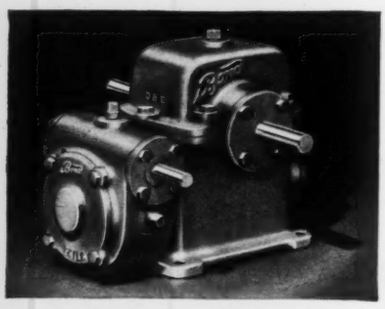
Write today for new specification catalog —just off the press.

4 CYCLE BRIGGS & STRATTON MILWAUKEE, WIS. U.S.A. GASOLINE MOTORS



*New*

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**Bond DOUBLE REDUCTION STOCK SPEED REDUCERS**

Now available in a wide range of sizes and ratios (up to 4,000:1) for both horizontal and vertical drives. Highest quality construction throughout. Every Designer or Builder of machinery should have a copy of the NEW BOND SPEED REDUCER CATALOG MGA-60, and the BOND STOCK GEAR CATALOG M-58.

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42 inches and 54 inches wide. It consumes less than 500 watts of electricity under normal operating conditions. The machine may be purchased in the 42 and 54 inch sizes.

## Meetings and Expositions

**Mar. 7-11—**

**American Society for Testing Materials.** Regional meeting at Seneca hotel, Rochester, N. Y., in conjunction with Spring group meetings of committees, Mar. 7. Plastics symposium, Mar. 9. C. L. Warwick, 260 South Broad street, Philadelphia, is secretary.

**March 14-17—**

**American Society of Bakery Engineers.** Annual meeting to be held at Edgewater Beach hotel, Chicago. Victor E. Marx, 1541 Birchwood avenue, Chicago, is secretary.

**March 15-17—**

**National Scale Men's association.** Annual meeting and exposition to be held at Sherman hotel, Chicago. R. O. Rask, 916 West Grove street, Bloomington, Ill., is secretary.

**Mar. 21-25—**

**American Society for Metals.** Third Western Metal congress and exposition. to be held at Pan-Pacific auditorium, Los Angeles. W. H. Eisenman, 7016 Euclid avenue, Cleveland, is secretary.

**Mar. 21-25—**

**American Welding Society.** Regional meeting of Pacific coast sections to be held at Biltmore hotel, Los Angeles. M. M. Kelly, 33 West Thirty-ninth street, New York, is secretary.

**Mar. 23-25—**

**American Society of Mechanical Engineers.** National Spring meeting to be held in Los Angeles. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

**Mar. 25—**

**Gray Iron Founders' society.** Annual meeting to be held at Statler hotel, Buffalo. W. W. Rose, 33 Public Square building, Cleveland, is executive vice president.

**Mar. 27-April 2—**

**American Ceramic society.** Annual convention to be held at Roosevelt hotel, New Orleans. Ross C. Purdy, 2525 North High street, Columbus, O., is secretary.

# Noise Reduction

(*Concluded from Page* 38)

.001 to .0002 inch and in many cases it may achieve no quieting whatever. In fact, it is quite common experience that special tool-room jobs where all tolerances are exceptionally small, and fits unusually close, may make considerably more noise than units built on ordinary production.

The practical approach in connection with greater accuracy of parts is to view this as a last resort to be attempted only in special cases where definite evidence has been obtained that such improvements in accuracy will produce the desired results at reasonable cost. The author has encountered few such instances.

7. SHIFT OF FREQUENCIES TO LESS IMPORTANT RANGES—It is often suggested that quieting can be obtained by shifting frequencies "beyond audibility". In cases of resonance it is often effective to shift frequencies to avoid resonance, but resonances are not very common in machinery noise. It is also advantageous if frequencies can be shifted below the low frequency cut-off. It is also true that higher frequencies are more objectionable to most people than lower frequencies, and shifts to lower frequencies are desirable, if possible.

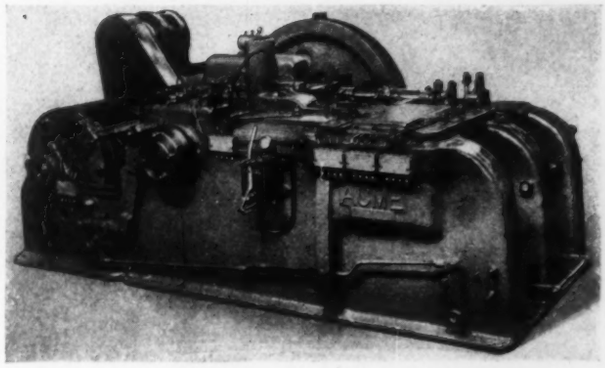
In most instances, however, the factors listed above are of minor consequence. For sounds of ordinary level the ear is about equally sensitive for all frequencies from 50 cycles to 10,000 cycles, a range of nearly 8 octaves. It is manifestly impractical to change speeds by 100 to one, or any such factor. Even if this were done, probably new components would be introduced.

In general, recent tendencies have been toward higher speeds in all types of machinery, and this tends to increase noise. The possibility of operating at speeds outside the audio-frequency range is very remote in most cases.

A review of these quieting methods shows that once a noisy machine has been built, about the only cure is to mount it resiliently, and to build an enclosure around it. Apparently there is no magic fluid to pour over it, nor no material which can be applied to soak up the noise.

If it is not feasible to enclose it, the problem then becomes one of reducing the noise at the source, or in keeping it from being transmitted to the surfaces which radiate it. These questions finally get back to a consideration of mobility-force products, both in general and in detail. This may not sound very attractive, but success has been attained by this attack.

We have found on many jobs that the most effective quieting means are inherently simple, and as obvious as A, B, C, *once they are understood.* The complexities of noise reduction exist in the determination of the fundamental mechanisms of noise production in individual cases.

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A Farval Centralized System of Lubrication will fully protect the bearings of the equipment you design and build, under all operating conditions.

Farval will provide the positive delivery of lubricant to all bearings on one machine or many. From one central pumping unit the Farval adjustable measuring valves at the bearings, deliver the lubricant under high pressure in exactly the amount required to provide proper lubrication at all times.

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Smooth

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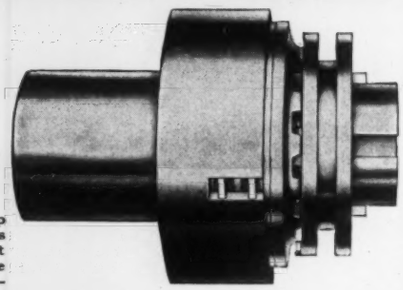

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MACHINE DESIGN
Penton Building, Cleveland, Ohio

# TOPICS

(*Concluded from Page 22*)

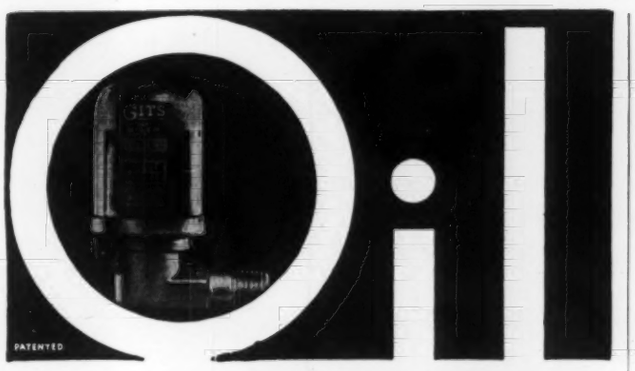
for a few weeks ago Dr. Robert Hutchings Goddard, foremost U. S. rocket experimenter, announced that he had built rockets which would shoot a mile into the air and attain a speed of 700 miles per hour. Two other scientists gave added impetus to rocket experiments by declaring the thrust of an ascending rocket constantly increases because thinning air gives less resistance and the pull of gravity diminishes as the contrivance reaches a high altitude. In theory, at least, they propounded, a three-step rocket (three mechanisms firing one after another) could reach a height of 5,100,000 feet (nearly 1000 miles) and a top speed of 11,000 miles per hour. At such a distance from the earth and with such speed, the earth's gravity would not be sufficient to pull it back and the rocket would travel onward into space.

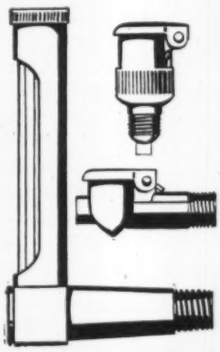
♦ ♦ ♦

New method for the continuous casting of metal direct from the molten state was described recently by Dr. Byron E. Eldred, president of the Engineers' club of New York. Rods, bars, tubes and plates produced by this method, known as "draw casting," according to Dr. Eldred, are of a distinctly superior quality to those cast in the conventional manner. Castings are said to be so dense as cast that there appears to be no increase in density on further working and annealing. Principle of the process is the orderly removal of heat to provide like crystal growth throughout the cast shape. Superheat from the metal is removed as a separate and distinct step in operation, followed by the uni-directional removal of latent heat in a separate path of heat flow. This provides for uninterrupted freezing and is evidenced in a metal such as copper by a single crystal many feet long in a ¾ inch rod.

♦ ♦ ♦

New York city is not only the richest city in the world, but it is located over one of the richest copper deposits in existence, the Consolidated Edison of New York tells us. More than 220,000,000 pounds of pure copper are contained in the 38,000 miles of the System's underground cable. In the last ten years, this company has purchased 142,000,000 pounds of the metal in pre-fabricated materials costing $58,000,000. Consolidated Edison and Commonwealth Edison of Chicago also share the distinction of installing the highest voltage cable in commercial use today. The cable is oil filled and carries 132,000 volts.



# CUPS

Seven hundred styles and sizes — to fill any industrial requirement — is proof of Gits leadership. The Gits line includes a complete range from regulation oil hole covers to special feature oilers — unbreakable sight wick feed, gravity feed or constant level oilers — oil cans — oil and grease seals and gauges. General catalog includes illustrations and complete information on all styles.

**GITS BROS**
**MANUFACTURING CO.**
**1861 S. KILBOURN AVE., CHICAGO**


# *POSITIONS*

## AVAILABLE OR WANTED

**WANTED:** Engineer and machine designer. Prefer one experienced in designing automatic paper specialty machinery. State experience and salary expected. Steady position for reliable engineer. Address Box 5796, Metropolitan Station, Los Angeles, Calif.

**WANTED:** Young man familiar with the application of hydraulic systems to machine design desires connection with pump manufacturer as sales engineer. Address Box 113, MACHINE DESIGN, Penton Building, Cleveland, Ohio.

**CLASSIFIED** advertisements are set in eight point Stymie bold face type, approximately eight words to a line. Rates are as follows:

Positions Available—20c a word, with a minimum charge of $10.00, which permits the use of fifty words.

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The box number will be counted as one line or eight words.

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There is no "bite test" for Ampco Metal, but subject it to any accepted, positive test for wear resistance—for tensile strength—for corrosion resistance and it will quickly prove these inherent qualities.

Only Ampco Metal, Inc. understands the method of combining copper, aluminum and iron to produce the "Ampco Phase" . . . the particular structural formation which provides Ampco Metal with these inherent qualities.

Genuine Ampco Metal is distinguished by the diamond trade mark reproduced here. It is available only from this Company and its four licensee foundries . . . in six grades of varying hardness and physical properties. The book "Ampco Metal—Its Uses in Modern Industry" will interest you.

**AMPCO METAL INC.**
**Dept. MD-3** **Milwaukee, Wis.**